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Edison Water Quality Laboratory

October 1970

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OIL CONTAINMENT SYSTEMS

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16. Abstract A wide variety of devices have been designed to prevent the spread of oil slicks over wide areas. An attempt was made to include a description of all of the various types of barriers currently in the published literature, under patent application, in the final stages of development, and those available as full scale commercial equipment today. Performance data, when documented by reliable and competent personnel, are also included. The containment systems listed may be broadly generalized into the following types: commercial floating booms, improvised booms, and air barriers. More than 50 ~~different~~ approaches to the problem are encompassed in this report, although many more systems are possible. ~~Additional information concerning specific devices or concepts can be obtained directly by contacting the manufacturer or inventor~~. (Lowry-Texas)

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Abstractor Mark V. Lowry

Institution Texas Univ, Austin

OIL SPILL CONTAINMENT SYSTEMS

FEDERAL WATER QUALITY ADMINISTRATION
U.S. DEPARTMENT OF THE INTERIOR

by

Oil & Hazardous Materials Research Section
Edison Water Quality Laboratory
Edison, New Jersey 08817

October 1970

WATER POLLUTION CONTROL RESEARCH SERIES

The Water Pollution Control Research Reports describe the results and progress in the control and abatement of pollution of our Nation's waters. They provide a central source of information on the research, development, and demonstration activities of the Federal Water Quality Administration, Department of the Interior, through in-house research, and grants and contracts with Federal, State, and local agencies, research institutions, and industrial organizations.

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ABSTRACT

Oil spill containment systems can be broadly characterized into the following types: commercial floating booms, multipurpose booms, improvised booms and air barriers. These systems are designed to prevent the spread of oil slicks over wide areas, thus providing for feasibile recovery, collection and disposal of the spilled product.

Containment systems, including those presently commercially available, as well as those under patent and development, are discussed and illustrated. Performance data, when documented by reliable and competent personnel, are also included. Systems have been listed in alphabetical order so as to indicate no product preference by FWQA.

Additional information, concerning specific devices or concepts can be obtained by contacting the manufacturer or inventor directly.

KEY WORDS: Oil containment systems, booms, air barriers, oil pollution control.

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INTRODUCTION

Oil and petroleum product spills can occur whenever and wherever these products are transported, handled or used. Spillages may be due to accidents or improper handling procedures at petroleum refineries, oil transfer terminals, onboard transport tankers, etc. Compared to chronic or continuous waste oil discharges, the accident situation is far less frequent. Severe accidents, however, such as the collision or stranding of a tanker at sea; the collapse of a waterfront oil storage tank; the derailing and rupture of a series of railroad cars may cause widespread pollution of the water environment together with untold consequences and damages. The critical situation may also be the direct result of natural forces such as devastating floods, hurricanes or earthquakes.

Resources that may be seriously affected and downgraded by chronic or accidental releases of petroleum products into a water body include: municipal, industrial and agricultural water supply sources; waterfowl, fish, and general aquatic flora and fauna; recreational interests both public and private such as beaches, shorefront properties and homes, marinas, pleasure boats, tourist centers, etc.; shellfish-harvesting; and the general public amenities normally associated with a pollution-free environment.

To prevent the spread of oil slicks over wide areas, many different types of oil-retention barriers have been developed. Oil booms may be deployed to encircle oil slicks, thereby reducing the area of coverage and increasing the thickness of slick and providing for feasible recovery, collection and disposal of the waste material. Oil booms may also be installed as a barrier to close off prescribed zones where spills may occur or where oils should not enter.

This report provides a description of various oil spill containment systems. Information was compiled from past and current literature, correspondence with manufacturers and their product bulletins, and from other technical sources.

These methods include conceptual design (only if such is described in the published literature), systems under patent application, systems in the stages of final development (with information release obtained from manufacturer), and various full-scale commercial equipment available today. The listing in this report is intended to be as complete as possible, but it is likely that some systems have been overlooked due to their recent development. Systems have been listed in alphabetical order so as to indicate no product preference. It must also be noted that a large majority of the data contained in this report were taken directly from published reports and manufacturers' "sheets" and, as such, reflects the adequacy and integrity of these information sources.

The oil spill containment systems described by this report may be broadly generalized into the following types: commercial floating booms, multipurpose booms, improvised booms, and air barriers. This report categorizes more than 50 different approaches to the problem of corralling and holding oil spills, although many more systems are possible.

It must be recognized that boom systems represent only one set of tools, although an important one, in effectively combating oil spills once they do occur. Oil spill booms are almost always deployed in conjunction with other equipment and methods for effective control and cleanup. In the simple case, this will mean a skimming or pickup device, whereas, for the serious spill it may mean any number of methods and techniques used concurrently to combat the situation.

There is a great scarcity of information on system performance and results obtained from particular boom systems when used in actual spills or field demonstrations. Therefore, performance criteria has been denoted only where specific documentation by competent technical personnel has been accomplished.

Experience has shown that a majority of the existing booms and oil containment systems have only limited use, for they generally fail to operate effectively under open sea conditions. It is hoped that new designs and approaches will be stimulated by ongoing research to expand the operational capabilities of booms, which in turn will lead to desirable commercial development of oil spill boom systems.

COMMERCIAL FLOATING BOOMS

SUMMARY TABLE

COMMERCIAL FLOATING BOOMS

	Boom	Stage of Development	Cost $/Ft.	Manufacturer
1.	Abribat Boom	Under Patent	Unknown	Address Unknown France
2.	Aqua Fence	Under Development	Unknown	Versatech Corporation Nesconset, Long Island New York
3.	Boom Kit	In Production	Unknown	Roberts Plastics Ltd. England
4.	Bristol Aircraft Company Boom	In Production	Unknown	Bristol Aircraft Company England
5.	British Petroleum Company Boom	Under Patent	Unknown	British Petroleum Company Finsburg Circus London, E. C. 2, England
6.	California Oil Company Boom	In Production	$2.45	California Oil Company Perth Amboy, New Jersey 07501
7.	Elo-Boom	In Production	$2.20	Helly J. Hansen A/S Moss, Norway
8.	English China Clay Company Boom	In Production	Unknown	English China Clay Company England

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Boom	Stage of Development	Cost $/Ft.	Manufacturer
9. Flexy Oil Boom	In Production	Unknown	Smith-Anderson Company, Ltd. 3181 St. James Street West Montreal, Quebec
10. Flo-Fence	In Production	Unknown	Logan Diving & Salvage Co. 530 Goodwin Street Jacksonville, Florida 32204
11. Galvaing Floating Booms	In Production	$16.20-$22.40	Gamlen Naintre & Cie 92 Clichy, 2, Rue Huntiziger, France
12. Gates Boom Hose	In Production	$50.00	Gates Rubber Company 6285 East Randolph Street Los Angeles, California 90022
13. Headrick Boom	Under Development	Expected Price $25-$35	Headrick Industries, Inc. 4900 Crown Avenue La Canada, California 91011
14. Jaton Boom	In Production	Unknown	Centri Spray Corporation 39001 Schoolcraft Road Livonia, Michigan 48150
15. Johns-Manville Spillguard Booms	In Production	$7.50-$20.00	Johns-Manville Company 22 East 40th Street New York, New York 10016
16. Kain Filtration Booms	In Production	$18.00-$23.00	Bennett International Service 302 A-5645 Topanga Canyon Boulevard Woodland Hills, California 91364

	Boom	Stage of Development	Cost $/Ft.	Manufacturer
17.	Marsan Inflatable Oil Barrier	In Production	$5.95 -$6.95	Marsan Corporation Box 83, Route 1 Elgin, Illinois 60120
18.	MP Boom	In Production	$9.75	Metropolitan Petroleum Company, Inc. 25 Caven Point Road Jersey City, New Jersey 07305
19.	Muehleisen Boom	In Production	Submitted Upon Request	Muehleisen Manufacturing Co. 1100 North Johnson Avenue El Cajon, California 92020
20.	Oscarseal - Hover Platforms	Patent Pending	Submitted Upon Request	The Rath Company P.O. Box 226 La Jolla, California 92037
21.	Oscarseal - Steel Boom	Patent Pending	$40 - $50	Morrison-Knudsen Company, Inc. Box 7808 Boise, Idaho 83707
22.	Red Eel	In Production	$2.60	Trelleborg Rubber Company, Inc. P.O. Box 178 225 Main Street New Rochelle, New York 10802
23.	Retainer Seawall	Patent Pending	$20.00 light duty $58.60 heavy duty	Environmental Pollution Systems 209 Profit Drive Victoria, Texas 77901

	Boom	Stage of Development	Cost $/Ft.	Manufacturer
24.	Sea Curtain	In Production	$ 2 -$ 4 light duty $10 -$15 heavy duty	Kepner Plastics Fabricators, Inc. 4221 Spencer Street Torrance, California 90503
25.	Sea Fence	Experimental	Unknown	Aluminum Company of America 4-63 48th Avenue Long Island City, N.Y.11101
26.	Sealdboom	In Production	$12.00	Uniroyal, Inc. 10 Eagle Street Providence, Rhode Island 02901
27.	Sea Skirt	Developmental	Unknown	Core Laboratories, Inc. Box 10185 Dallas, Texas 75201
28.	6-12 Boom	In Production	$ 9.75	Worthington Corporation Pioneer Products Division P.O. Box 211 Livingston, New Jersey 07039
29.	Slickbar Oil Boom	In Production	$3.85-$ 6.80, 4" $5.25-$12.25, 6"	Neirad Industries Saugatuck Station Westport, Connecticut 06880
30.	SOS Booms	In Production	$5.50-$16.50	Surface Separator Systems 103 Mellor Avenue Baltimore, Maryland 21228

Boom	Stage of Development	Cost $/Ft.	Manufacturer
31. Transatlantic Plastics Boom	Unknown	Unknown	Transatlantic Plastics Ltd. England
32. T-T Boom	In Production	$6.77-$8.08	East Coast Service, Inc. 343 Washington Street Braintree, Massachusetts 02184
33. Warne Booms	In Production	$15.00-$36.00	Surface Separator Systems 103 Mellor Avenue Baltimore, Maryland 21228
34. Water Pollution Controls Boom	Patent Pending	Unknown	Water Pollution Controls, Inc. 2035 Lemoine Avenue Fort Lee, New Jersey 07024

ABRIBAT BOOM (FRANCE)

The Abribat Boom was patented in France shortly after the Torrey Canyon accident in 1967. Little is known of the Abribat Boom except that it is made of a rubberized material attached to foam plastic flotation blocks and tied together with plastic ropes. It is reported that this boom will provide an effective freeboard of approximately 24 inches. The design and development stages of the Abribat Boom are not known at this time.

Inter-Office Memo by U. S. Corps of Engineers, Hydraulic Design Branch, August 3, 1967.

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AQUA FENCE

Aqua Fence is Versatech Corporation's name for its water borne system of containing and controlling the spread of oil on the water's surface. Aqua Fence is in the conceptual stage and will require engineering analysis, development and testing to bring it to a deliverable hardware status. A conceptual scale model of the Fence reportedly has been constructed and tested satisfactorily in simulated wind and sea conditions.

The Aqua Fence system is conceived as a helicopter-transportable package which can be flown to the site of an oil slick. The package will consist of the machinery and sufficient raw materials for fabricating a continuous Aqua Fence of optimum length. Additional raw materials can be stationed at designated supply points.

The operation of fabricating Aqua Fence will consist of automatically feeding two rolls of plastic sheet through forming machinery which folds and joins the sheets into a continuous row of "pockets". Flotation will be provided by inflating the pockets with air during the sealing operation. Tests

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under actual conditions will be required to obtain the most satisfactory system configuration. At the present time, several different cross-sectional shapes are being studied.

Information provided by Versatech Corporation, Nesconset, Long Island, New York

BOOM-KIT (GREAT BRITAIN)

The Boom Kit is manufactured by Roberts Plastics Ltd. of Great Britain. The kits may be stored in central depots and the parts assembled to make "a deflection boom" of any desired length. Each kit contains two buoyancy floats and a mesh curtain, together with clamps, shackles, washers and bolts. Ballasting is recommended by weights suspended from end shackles. Further data on dimensions, costs, and capabilities of this system are not available at this time.

"Clearing Up the Oil", Paper published in Petroleum Magazine; however, volume, number and date of this article are not known.

BRISTOL AIRCRAFT COMPANY BOOM (GREAT BRITAIN)

In 1967 the Bristol Aircraft Company developed a boom comprised of 10-inch diameter fiberglass pipe onto which strips of marine plywood, 12 and 9-inches wide, were attached to the top and bottom edges of the pipe. The fiberglass pipe is provided in 20-foot lengths with both ends sealed to permit flotation. In the upright position this boom has a height of 31 inches, consisting of the 12-inch strip of plywood serving as freeboard, the 10-inch flotation unit, and the 9-inch plywood board serving as the submersible section. The structure is maintained upright by 28-pound weights attached to the 9-inch plywood strip and positioned at 5-foot intervals along the boom.

Any number of 20-foot sections may be joined together to give the desired length of boom. The assembly is moored to oil drums every 100 feet with support cables tied to marine anchors.

Inter-Office Memo by U. S. Corps of Engineers, Hydraulic Design Branch, August 3, 1967.

BRITISH PETROLEUM COMPANY BOOM (GREAT BRITAIN)

The British Petroleum Company boom, described in a British patent application, comprises resilient foam material surrounding one or more buoyancy chambers extending along the length of the boom. The buoyancy chambers, which are reportedly non-permeable to air or liquids to ensure inflatability, are lined or coated with canvas or other flexible materials. The number of buoyancy chambers necessary for the boom will depend upon the buoyancy and characteristics of the absorbent foam, and desired ease in handling the boom. The buoyant chambers are also constructed in such a manner they may be compressed to remove oils absorbed in the foam material.

The inventor claims this boom system to be lighter and less expensive than existing systems, and due to its flexibility it will closely follow the contour of the water surface even under moderately-choppy conditions. It is not known whether the British Petroleum Company concept has been translated into system design and development.

Patent Specification No. 1,028,470, Great Britain, date of filing given as July 22, 1964; Specification published May 4, 1966, Great Britain.

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CALIFORNIA OIL COMPANY BOOM

The California Oil Company has employed a polyethylene floating boom for containing and collecting oil spillages at its Perth Amboy, New Jersey terminal facilities. This boom is made up of a plastic float with a lead-weighted fin extending six inches below the water surface. Floats are available in 3, 4 and 6-inch diameter sizes depending upon freeboard desired and site conditions.

The 4-inch polyethylene boom is quoted at $2.45 per foot. The company reports that the boom can be deployed and set in place within 15 minutes or less. Also, because of their flexibility and light-weight, the booms may be readily transferred and stored close to the intended points of use.

"Plastic Floats Contain Harbor Spills", Oil and Gas Journal, p. 155, September 3, 1962.

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ELO-BOOM (NORWAY)

The Elo-Boom[1], manufactured in Norway, is available in 82-foot lengths at a cost of approximately $2.20 per foot. It consists of a flotation unit 8-inches in diameter, from which hangs a skirt of 16 inches. The flotation chamber contains a series of tubes which are filled with carbon dioxide gas from standby compression cylinders. Chain ballasting is provided on the skirt and the assembly has a total weight of 3.5 pounds per foot. Further information on materials of construction, and system performance and handling, was not readily available.

---

[1] Inventor of Elo-Boom given as Helly J. Hansen A/S, Moss Norway.

"Containing and Removing of Oil Spillage from Water Surfaces", Cornelssin, J., MPD Division, Paper C-9, Pollution Abatement Conference, The Hague, 1963.

ENGLISH CHINA CLAY COMPANY BOOM (GREAT BRITAIN)

The English China Clay Company Boom consists of rubber belting, 1/2-inch thick by 24 or 30 inches wide, and maintained in the vertical position by "outriggers". The outriggers, presumed to be a continuous float on both sides of the boom, are made of 4-inch plastic pipe filled with plastic foam for additional buoyancy. Metal straps serve to hold the outriggers to the belting, but were reported as being "too light". Sections of 100 feet or more are assembled near shore, then towed to the operational site for final fastening and anchoring. The English China Company boom was reported ready for testing in August 1967 in England, but it is not known if these tests were conducted.

Inter-Office Memo by U.S. Corps of Engineers, Hydraulic Design Branch, August 3, 1967.

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FLEXY OIL BOOM

Flexy Oil Boom, made in Canada by Smith-Anderson Co., Ltd., Montreal, Quebec, is constructed of 36-inch wide PVC nylon fabric. When in use, the skirt depth is 24 inches and the freeboard 12 inches.

Available in 100-foot lengths, the nylon fabric has a tensile strength of 450 pounds per inch and is fitted with aluminum stiffeners for rigidity. Stability is provided and maintained by floats and lead ballast weights spaced two feet on center, and galvanized chain at the skirt bottom running the full length of the section. Weight of a 100-foot section, including floats and ballast, is reported at 250 pounds.

For attaching one or more sections together, each end of the boom is equipped with five snap hooks placed two feet from the end, and five matching outlets on the adjoining section; thus providing an overlap of two feet at the junction or connection points. For extra strength, the chain ballast at the skirt base is shackled together.

Information provided by Hurum Shipping and Trading Co., Ltd., 300 St. Sacrament Street, Montreal, Quebec, sole distributors for Flexy Boom; January 1970.

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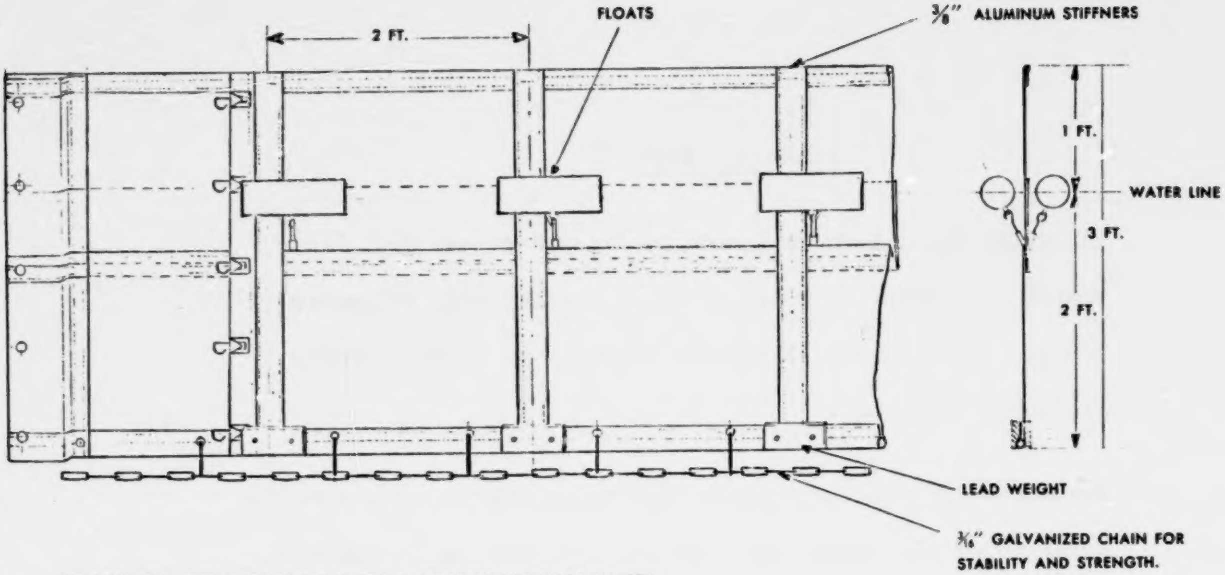
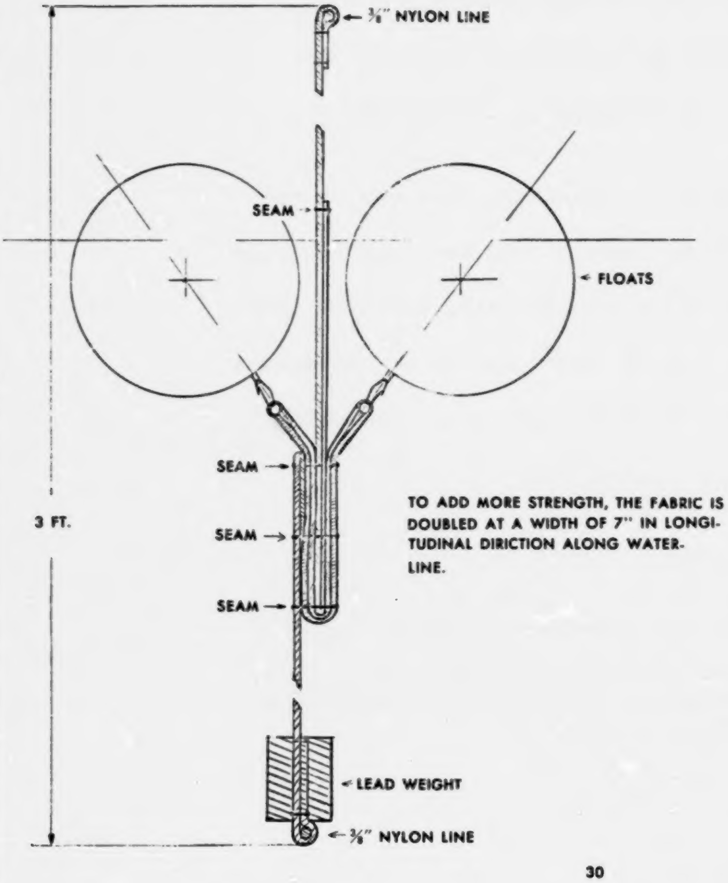

2 FT.
FLOATS
3/8" ALUMINUM STIFFNERS
1 FT.
WATER LINE
3 FT.
2 FT.
LEAD WEIGHT
3/16" GALVANIZED CHAIN FOR STABILITY AND STRENGTH.

THE ALUMINUM STIFFNERS ARE SEWN INTO A SEPARATE DOUBLE LAMINATED POCKET BEFORE SEWN ON TO THE FABRIC AND EACH STIFFNER SPACED AT TWO FEET CENTERS.


3/8" NYLON LINE
SEAM
FLOATS
SEAM
SEAM
SEAM
3 FT.
LEAD WEIGHT
3/8" NYLON LINE

TO ADD MORE STRENGTH, THE FABRIC IS DOUBLED AT A WIDTH OF 7" IN LONGITUDINAL DIRICTION ALONG WATERLINE.

Figure 1
FLEXY OIL BOOM

FLO-FENCE

Flo-Fence, an inflatable barrier, available in various diameters and weight skirt lengths, is manufactured by Logan Diving and Salvage Company, Jacksonville, Florida. Constructed of fireproof, acid, and oil resistant coated fiber, the barrier is available in 100-foot lengths, weighs 95 pounds per 100-foot section, and can be stored in an area of 6 feet by 5 feet by 3 feet.

Company picture with description obtained December 1969 from Logan Diving and Salvage Company, 530 Goodwin Street, Jacksonville, Florida 32204.

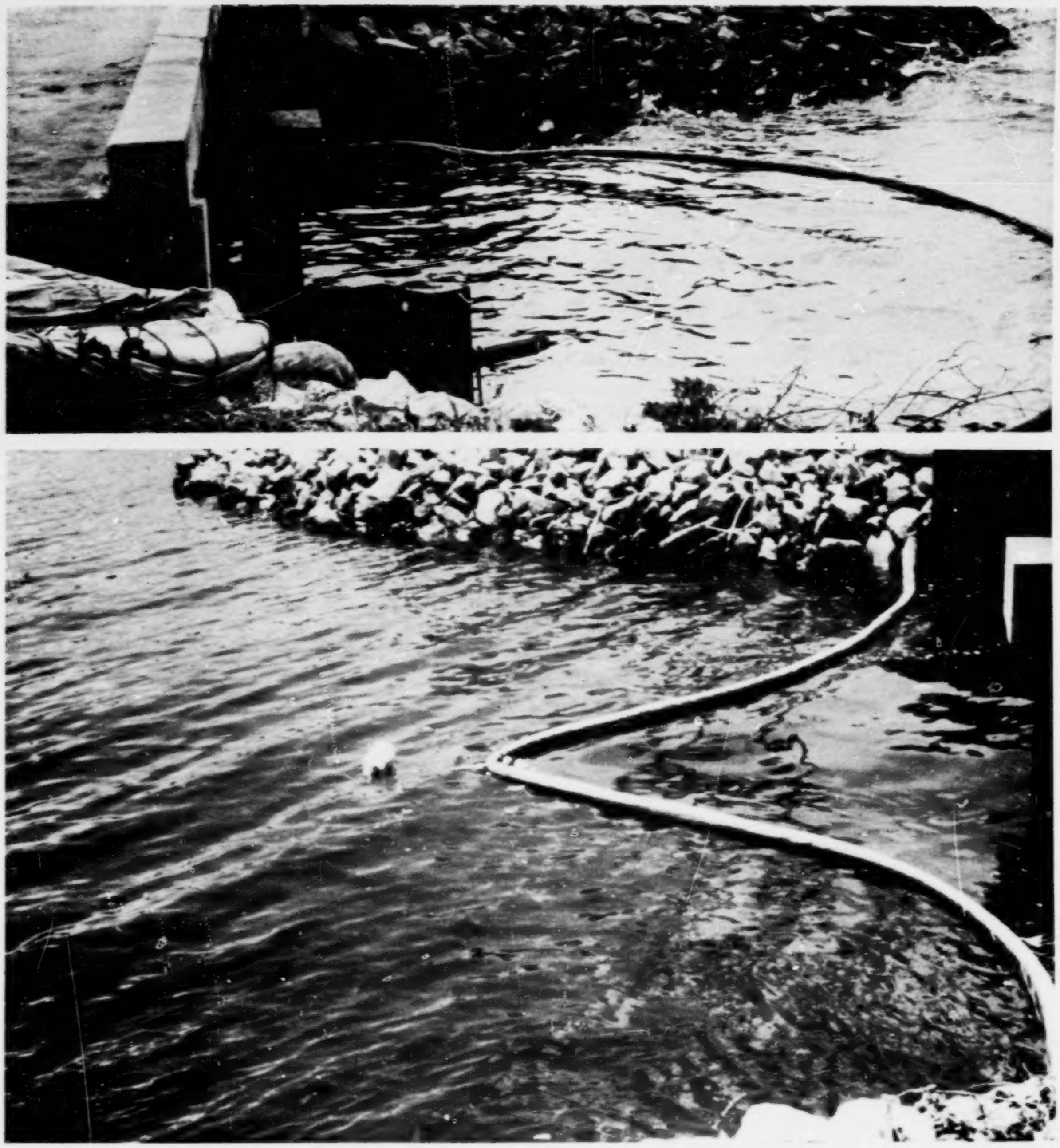


Figure 2 FLO-FENCE BOOM

GALVAING FLOATING BOOMS (FRANCE)

Galvaing Booms are composed of short compact units of rigid floats inserted into plastic-coated fabric panels or PVC-coated asbestos panels. Individual units (consisting of a vertical panel and a float attached to each side of the panel) are coupled together by neoprene rubber or a plastic-coated fabric. To avoid unnecessary strain on the panels and prevent them from being pulled out of shape, a cord or metallic chain is inserted into the top and bottom hems of the panels running the length of the barrier.

Individual units are only 3.2 - 3.9 feet long to provide for maximum flexibility of the boom. A standard section of the Galvaing barrier comprises either 4 or 5 units depending upon the type of barrier. The length of a standard section varies from 16 to 20 feet. Security hooks are provided to link any number of standard sections together for total length of boom desired. The barrier extends approximately 8 inches above water and 8 inches below.

Three types of Galvaing barriers are available: (1) The Emergency Barrier; (2) The Ballast Water Removing Barrier; and (3) The Fire Barrier.

The Emergency Barrier is made up of polyurethane floats attached onto plastic-coated fabric panels and may come equipped with skirt and ballast fixed to the bottom of the panels. The Ballast Water Removing Barrier appears similar to the Emergency Barrier except a special skirt is attached to the bottom of the panels giving a total submersible depth of about 3 feet. When used for the purpose of retaining and separating oils from ballast water, the manufacturer recommends weighting of the skirt. The two types of barriers described above are relatively light-weight, approximating 1.1 pounds per foot without auxiliary skirt and ballast.

The Fire Control Barrier is designed for containing oil and petroleum product spills within harbors and other similar areas, but is also intended for encircling and minimizing the spread of petroleum fires on water. The Fire Barrier is like the Emergency Barrier in principle. Major differences are aluminum alloy floats inserted into PVC-coated asbestos cloth, and the units being coupled by plastic-coated asbestos and galvanized steel chain. The Fire Control Barrier is available in standard and heavy-duty forms. The standard fire barrier has an overall height of 13 inches, weighs approximately 4 pounds per foot, and cost given in 1967 was $16.20/foot - FOB Marseilles, France. The heavy-duty fire barrier has an overall height of 18 inches, weighs approximately 8 pounds per foot, and 1967 cost quotations were given as $22.40/foot. After use in a fire, considerable repair work is indicated even for the Fire Control Barriers. One to three months delivery time may be expected for Galvaing barriers and/or replacement parts.

The manufacturer recommends that when the Galvaing boom is towed to the site of an oil spill, it should not be pulled at a speed exceeding one knot. It is also suggested that these booms not be deployed against a fast-moving current nor placed directly across a river or waterway. Rather, the boom should be moored at a desirable angle of closure with the shoreline, enabling recovery of oils in the slower-moving downstream areas of the boom.

Product bulletins received from Gamlen Naintre and Cie (Subsidiary of Gamlen Chemical Co.), 92 Clichy, 2, Rue Huntiziger, France, 1969.

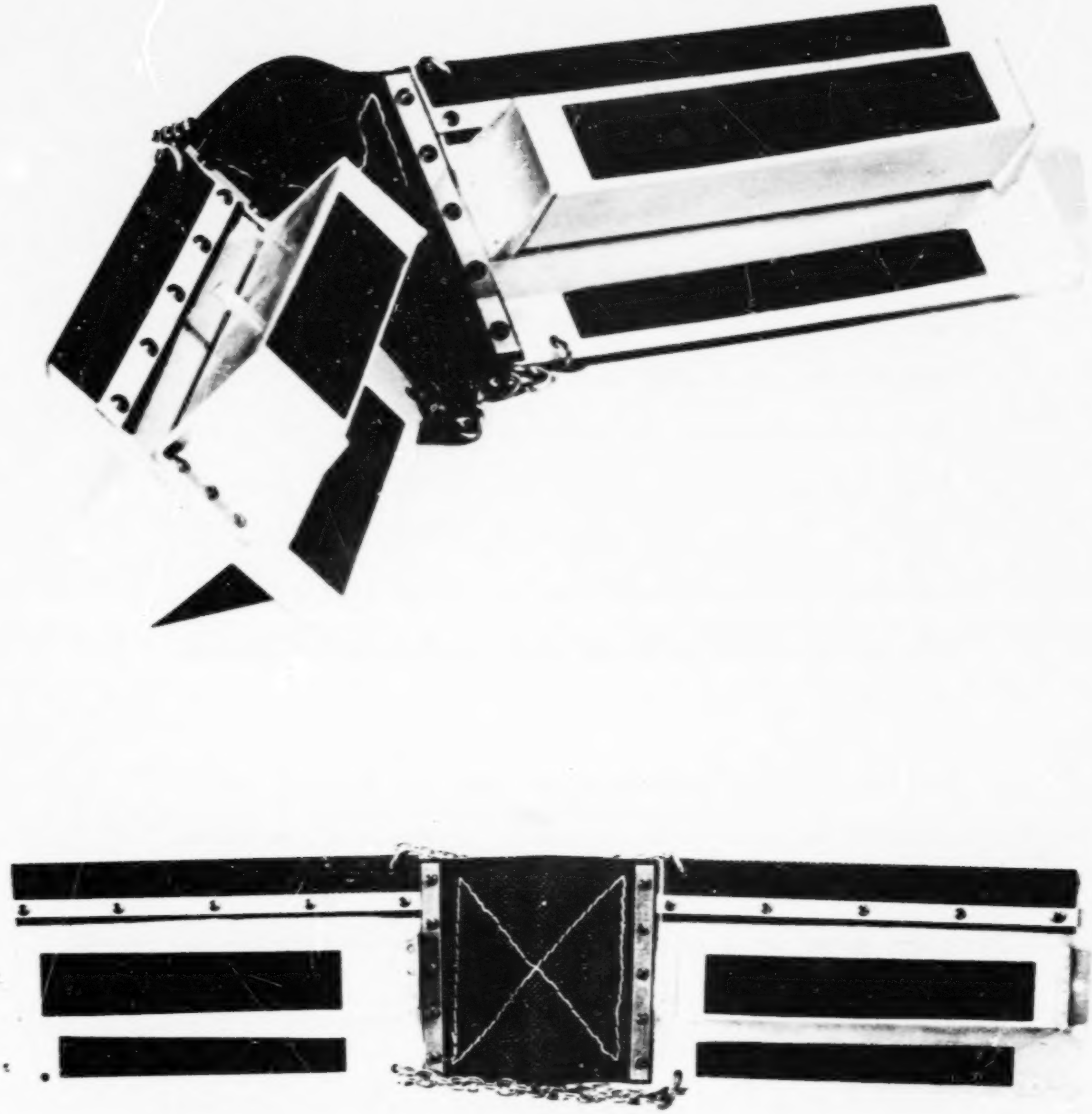


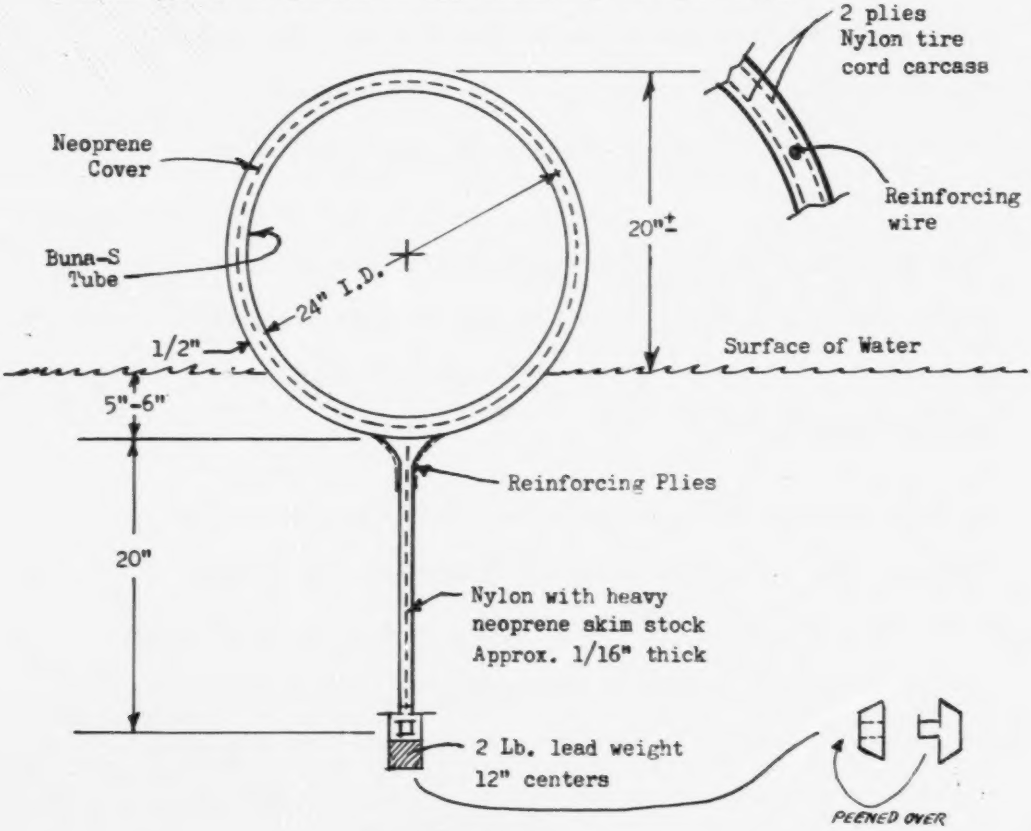
Figure 3 GALVAING BOOM

GATES BOOM HOSE

The Gates Boom Hose is a 25-inch (outer diameter) floating cylinder to which is attached a 20-inch deep skirt ballasted by two pounds of lead weight per running foot of skirt. The one-half inch thick hose consists of two piles of nylon tire cord carcass reinforced with spiral wire, with neoprene outer cover and inner high-tensile Buna-S tube. The Gates Boom Hose rides 19-20 inches above the water surface and 5-6 inches below (excluding skirt). The 1/16-inch thick neoprene-nylon skirt is built into the hose with reinforcing piles, and comes equipped with grommets along the bottom edge of the skirt to attach lead weights and with grommets at the ends of skirt section to splice adjacent lengths together.

The hose assembly is available in lengths of approximately 25 feet. The ends of the hose are reinforced with fiberglass, also containing a built-in aluminum nipple and aluminum round plate welded to the nipple. Adjacent hose sections are fastened together by stainless steel bands over the end plates. It is noted the Gates Hose is a non-inflatable boom.

It is reported the assembly is flexible and has high-tensile strength capable of withstanding end loads of 30,000 pounds. When the Gates Boom Hose exceeds 400 feet in length, the manufacturer recommends that additional reinforcement be provided by steel cables attached to the hose nipples. Boom price is quoted at approximately $50 per foot.


2 plies
Nylon tire
cord carcass
Neoprene
Cover
Reinforcing
wire
20"±
Buna-S
Tube
24" I.D.
1/2"
Surface of Water
5"-6"
Reinforcing Plies
20"
Nylon with heavy
neoprene skim stock
Approx. 1/16" thick
2 Lb. lead weight
12" centers
PEENED OVER

Hose Cross Section

Figure 4 GATES BOOM

Information received from the Gates Rubber Company,
999 S. Broadway, Denver, Colorado 80217, November 1969.

HEADRICK BOOM

Headrick Industries, Inc., La Canada, California, has developed a series of air-inflatable booms for different sea states. Essentially, the booms consist of flotation cylinders positioned directly over a submersible cylinder. The floating tubes are air-filled and slightly pressurized whereas the bottom or center tube is filled with water, providing ballast and stability to the boom assembly. The tubes are manufactured as a single continuous unit with a membrane inter-connecting the tubes and made from the same coated fabric from which the tubes are constructed. A steel towing and/or mooring cable is integrated and enclosed permanently in a loop of fabric attached to the lowermost exterior of the water tube. Construction material for the boom is high-strength PVC over nylon fabric.

Air tubes are segmented every 50 feet and the water tube every 20 feet so as to isolate a damaged chamber and still maintain near complete integrity of the boom. Each chamber is separately filled with air and water from a service vessel. The manufacturer claims that the inflatable tubes will retain their air supply for several weeks, and that pressure differential between high and low temperatures during the day will present no problems.

For applications where the boom must remain in the water for long periods of time without surveillance, the manufacturer suggests the air tubes may be filled with polyethylene, expanded styrofoam, or similar materials. However, in this case there is some loss of flexibility and the boom is less conveniently stored after use.

Weight of the prototype boom, made up of three 10-inch diameter tubes, was approximately 1.8 pounds per foot. Booms expected to be made available in future production include the 10, 13, 16 and 22-inch tube sizes with estimated boom weights between 1.8 and 3.6 pounds per foot, and an expected price range of $25 - $35 per foot. Booms will probably be marketed in 1,000-foot lengths made up of four 250-foot sections together with necessary coupling attachments and hardware.

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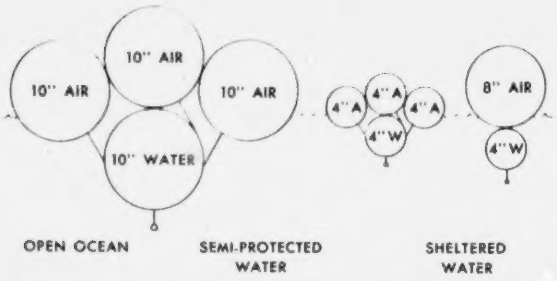
(1) "The Use of Coated Fabrics in Containment of Petroleum", Paper presented at September 11, 1969 Meeting of the American Petroleum Institute, Los Angeles Basin Chapter, by Richard T. Headrick, Firestone Coated Fabrics Company.

(2) Information received from Headrick Industries, Inc., 4900 Crown Avenue, LaCanada, California 91011


10'' AIR
10'' AIR
10'' AIR
10'' WATER
4'' A
4'' A
4'' A
4'' W
8'' AIR
4'' W
OPEN OCEAN
SEMI-PROTECTED WATER
SHELTERED WATER

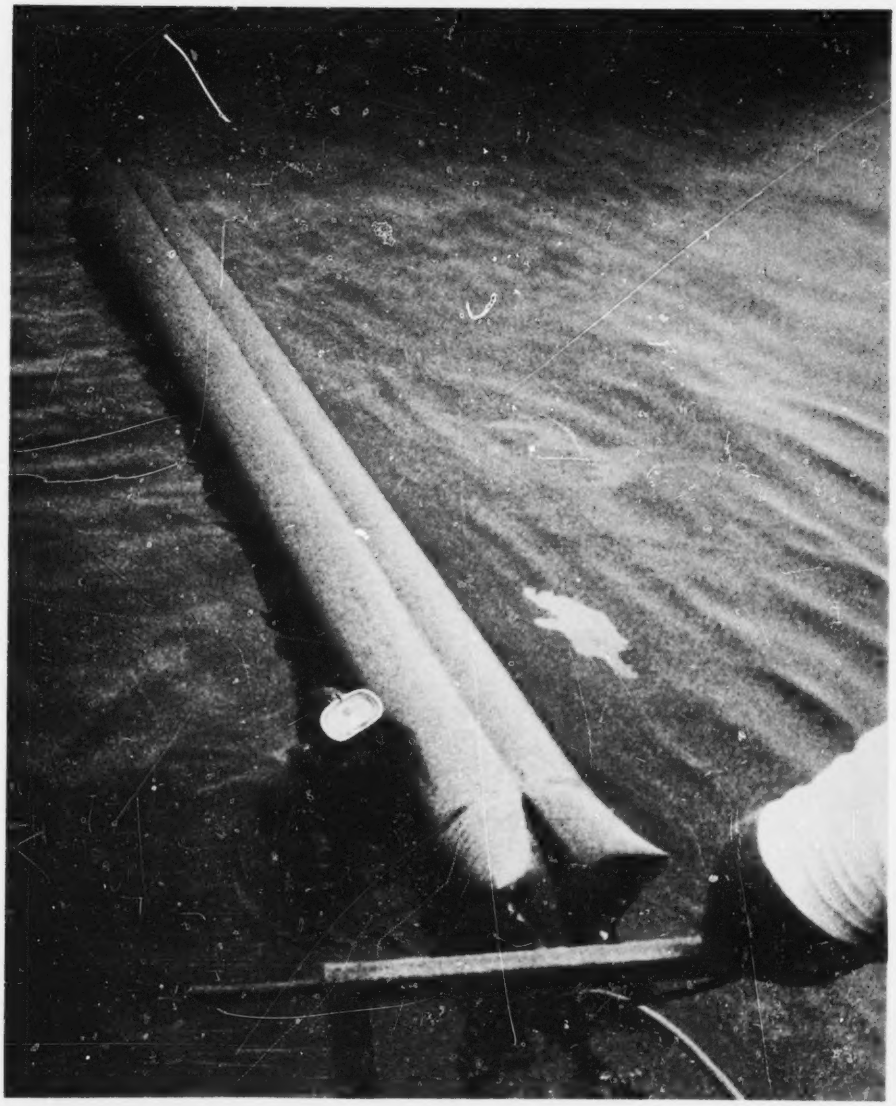


Figure 5
HEADRICK BOOM

JATON BOOM

"Jaton" is the tradename for a floating oil retainer, which is of the float and skirt design. The flotation pocket contains a unicellular plastic foam cylinder measuring 4 inches in diameter by 9 feet long. The foam flotation cylinders, in standard nine foot lengths, are thermetically sealed in individual, air-tight compartments.

The curtain extends down from the underside of the flotation element and is made of vinyl-impregnated nylon. The curtain depth comes in various sizes, 6 to 24 inches.

Steel keel weights are stitch-enclosed along the bottom edge of the curtain to span the length of each flotation segment. The keel weights are galvanized steel bars, 4 inches in length and 3/8-inch diameter. Grommets are No. 3 brass spur.

Costs for this boom may be obtained from Centri-Spray Corporation.

Product bulletin obtained in December 1969 from Centri-Spray Corporation, Centri Clere Filter Division, 39001 Schoolcraft Road, Livonia, Michigan 48150.

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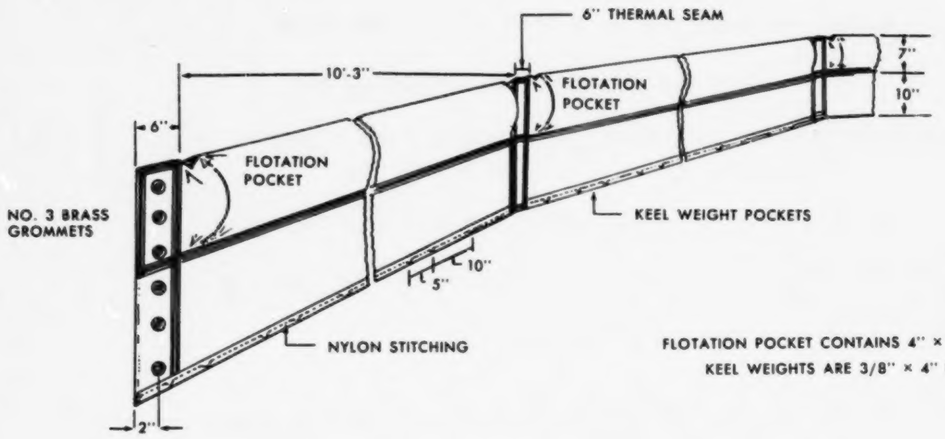
FLOATING OIL RETAINER

REPRESENTATIVE SAMPLE: 4" DIA. FLOTATION MEMBER WITH 10" CURTAIN


6" THERMAL SEAM
10'-3"
6"
FLOTATION POCKET
FLOTATION POCKET
7"
10"
NO. 3 BRASS GROMMETS
KEEL WEIGHT POCKETS
10"
5"
NYLON STITCHING
2"

FLOTATION POCKET CONTAINS 4" × 9' DOW ETHAFOAM CYLINDER
KEEL WEIGHTS ARE 3/8" × 4" HOT DIPPED GALV. RODS

Figure 6
JATON BOOM

JOHNS-MANVILLE SPILLGUARD BOOMS

The Johns-Manville "Spillguard" boom is a sheet fence which rides vertically in the water. The boom consists of 10-foot lengths of asbestos rubber sheet. A neoprene flotation liner is cemented firmly to both sides of the boom running the length of the section and enabling the sheets to ride upright at the waterline near the mid-point of the flotation liner. Each of the 10-foot sections is connected to the next section with a 2-ply reinforced rubber hinge. Nine sections, plus the hinges, are combined to form a 100-foot length. The Spillguard boom is available in two sizes:

No. 411 - 4 inches above the water surface and 11 inches below

No. 1224 - 12 inches above the water surface and 24 inches below

The Spillguard boom is furnished in standard lengths of 100-feet and a special connection is provided for joining the standard lengths. Bulkhead connectors are also available which provide a seal between the end of the boom and the stationary vertical member; the connectors allow for free movement of booms with the rise and fall of tides.

The manufacturer reports that the No. 411 boom can be handled by two men in a small outboard-driven boat. The No. 411 boom weighs approximately 3 pounds per foot. The No. 1224 boom, which weighs about 9 pounds per foot, reportedly can be deployed and recovered by four men. During a demonstration in Chesapeake Bay, the company reports that 300-feet of the No. 1224 were connected and set by four men in less than 10 minutes; recovery of the boom required less than 15 minutes hauling aboard a harbor tug.

Costs recently quoted for the Nos. 411 and 1224 oil booms are respectively $7.50/ft. and $20.00/ft. The connection for joining standard sections is included in the above costs, whereas bulkhead connectors are quoted at $75 and $125 respectively for the Nos. 411 and 1224 booms.

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(1) Johns-Manville product bulletins, Manville, New Jersey and New York, New York, 1968 and 1969.

(2) Personal communication with Johns-Manville Sales Office, New York, New York, October 1969.

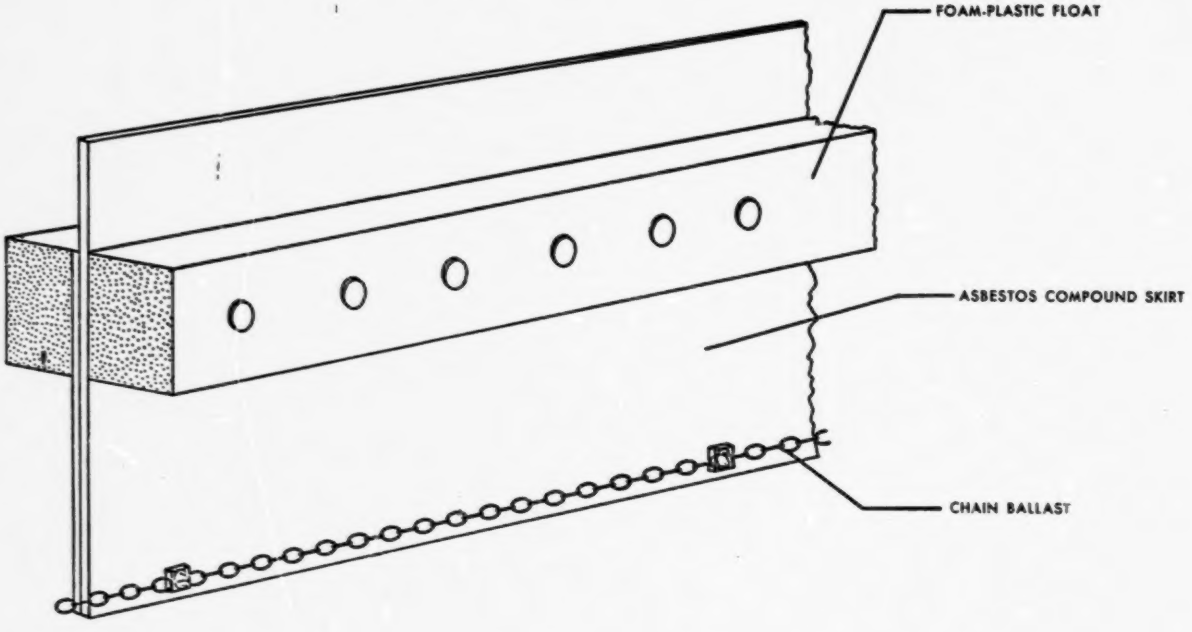
FOAM-PLASTIC FLOAT
ASBESTOS COMPOUND SKIRT
CHAIN BALLAST
J-M SPILLGUARD BOOM

Figure 7
J-M SPILLGUARD BOOM

KAIN FILTRATION BOOMS

The Kain Filtration Boom essentially comprises a deep vertical barrier supported by flotation chambers on each side of the curtain. Approximately one-third of the curtain boom protrudes above the water surface (freeboard) and two-thirds is immersed below the waterline. Three types of booms are reported available, including the 3-foot curtain intended principally for use in marinas and for surrounding tankers; the 5-foot curtain for harbor use; and the large 8-foot curtain for offshore sea operations.

The vertical section of the boom is basically a "sandwich" structure. The centerpiece consists of wire mesh or one-half inch steel-cable net (depending upon type of boom) sandwiched on each side by galvanized steel industrial cyclone fencing, and finally encased with filtration fabric comprising the outer sides of the boom. The steel-cable net is woven into 8-inch squares with a longitudinal strength of 400 tons safe working load. The two layers of cyclone fencing serve as a support for the filtration material on each side of the steel-cable net. The filtration fabric is constructed of a polypropylene fiber mechanically enmeshed and heat-fused. The filtration material reportedly allows water to freely pass through

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in both directions, but precludes the passage of floating oils, etc. A standard section of offshore boom would appear to be 150 feet long.

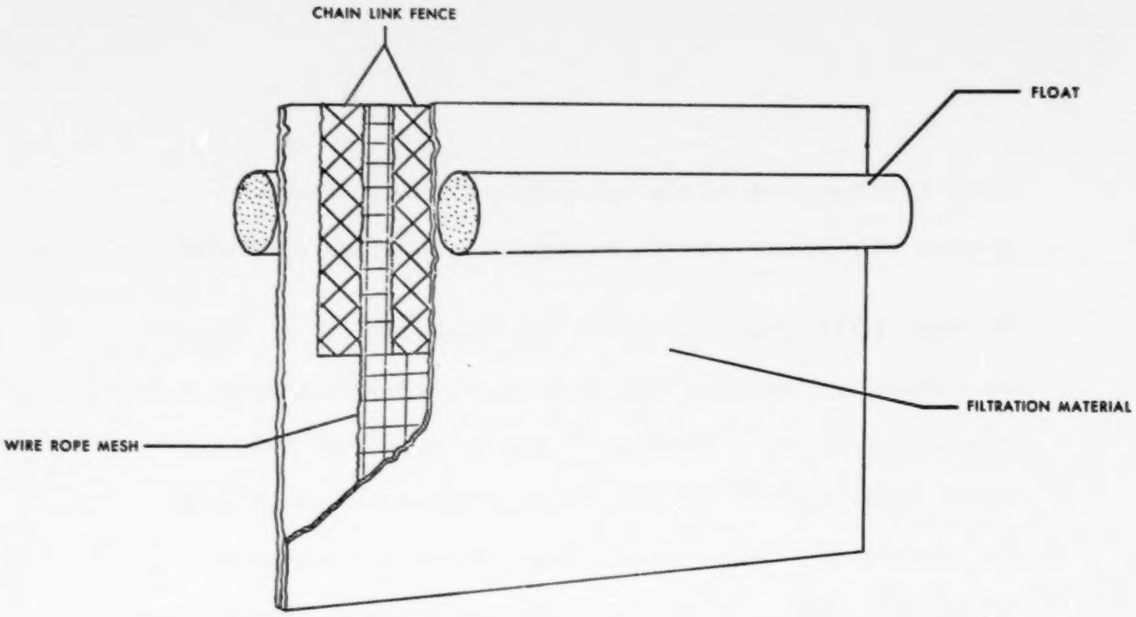
Flotation chambers providing for proper immersion depth of the curtain are firmly attached to both sides of the curtain by 3/8-inch galvanized wire (through the barrier), thimbles, clips and snaphooks. The flotation cylinders are nylon-vinyl sleeves stuffed with polyurethane bags which in turn are filled with styrofoam pellets. The assembled cylinders for the offshore boom are 14-inches in diameter and manufactured in 18-foot long sections. Tow cables, ropes, grommets, shackles, cables and thimbles represent auxiliary equipment used in completing the Kain Filtration Boom.

The heaviest component of the Kain offshore filtration boom is the curtain element which weighs approximately 1,000 pounds for a 150-foot section. All elements for the offshore boom are stored and shipped together for the standard 150-foot length. The standard length can be reduced into a volume of 800 cubic feet weighing approximately 1,250 pounds.

The filtration boom at sea reportedly has considerable freedom of movement and can encompass 360 degrees of travel.

The Kain filtration boom may be purchased outright or leased on a short or long-term basis from Bennett International. Purchase costs for 1,000-feet of marina and harbor boom are respectively $18,000 and $23,000; no purchase price is given for the offshore boom. Weekly rental rates for the marina, harbor and offshore booms per 1,000-feet usage are respectively $1,800, $2,300 and $2,900 (prices do not include auxiliary services, and minimum of 2 weeks use for the offshore boom). Other lease plans are also available.

"Oil Pollution Defense", bulletin and technical data received from Bennett International Services, Inc., Woodland Hills, California, September 1969.


CHAIN LINK FENCE
FLOAT
FILTRATION MATERIAL
WIRE ROPE MESH

KAIN BOOM

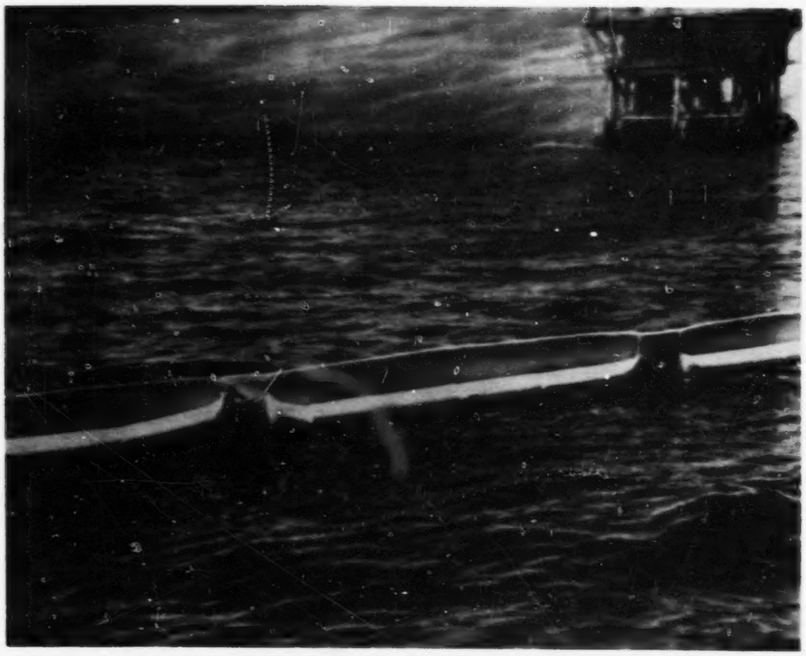


Figure 8
KAIN FILTRATION BOOM

MARSAN OIL BARRIER

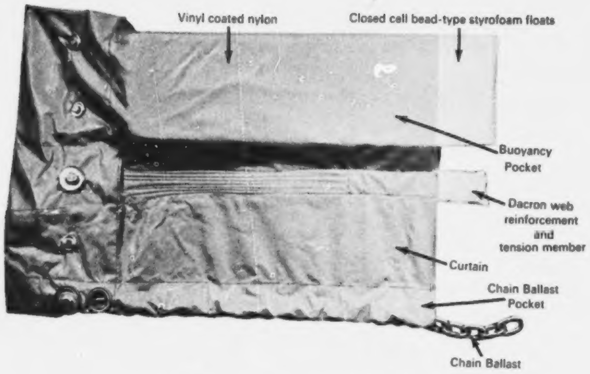
The Marsan Oil Barrier is essentially a plastic curtain with an air or styrofoam filled buoyancy pocket, a stiffened freeboard portion above the pocket, and drop curtain below the buoyancy pocket.

The upper few inches of the boom riding above the water surface are described as the stowage fin with grommets located on two-foot centers. Stowage fin stiffeners are provided at each end of a standard barrier section. The buoyant pocket is sewn into the curtain separating it from the stowage fin and drop curtain. The upper sewline contains a dacron tension line running the full length of boom. At the bottom edge of the drop curtain is found a pocket for inserting chain ballast providing vertical orientation of the Marsan barrier within the water. The standard Marsan barrier has a drop curtain 15 inches in depth but 24 and 36-inch curtains are also available.

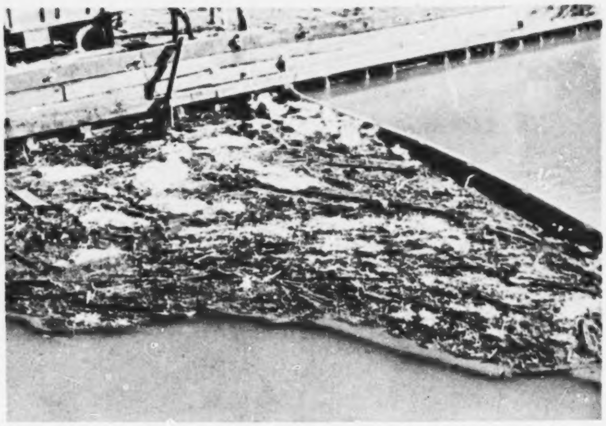
The barrier is provided in standard lengths of 50 or 100-feet and is constructed of vinyl-covered nylon material, which is fire-resistant and reportedly remains flexible at temperatures considerably below 0°F. The standard boom sections would appear linked together by a series of snap connectors together with special provisions for extending a hose line through the sections when air inflation is used. Self-actuating buoyant air reservoirs, which serve to inflate the hose in the buoyancy pocket, are spaced every 200-feet on the barrier.

The cost of the standard Marsan barrier (with 15-inch drop curtain) is $5.95/ft., including actuating air reservoirs. Inflatable barriers with 24 and 36-inch drop curtains are quoted at $6.95/ft. A relatively small metal storage rack for holding 500-feet of barrier may also be purchased for $175 and a zippered canvas cover over the storage rack is $75. Prices are F.O.B., Chicago, Illinois.

Product Bulletins received from the Marsan Corporation, Chicago, Illinois, 1969.


Vinyl coated nylon
Closed cell bead-type styrofoam floats
Buoyancy Pocket
Dacron web reinforcement and tension member
Curtain
Chain Ballast Pocket
Chain Ballast

Cutaway view showing construction of Marsan Oil Barrier and method of segmenting sections



Marsan Oil Barrier confining oil-soaked straw and heavy load of debris

Figure 9 MARSAN OIL BARRIER

MP BOOM

Metropolitan Petroleum Company, Inc., manufacturers the MP Boom, which essentially consists of a 6-inch diameter, closed cell polystyrene bead filled flotation chamber, a 12-inch submerged skirt, and a solid weighted keelson to provide ballast. The flotation material is enclosed in a vinyl envelope for added protection in case of a break in the synthetic fabric covering.

This particular boom is recommended by the manufacturer for use on sheltered water where wave height is less than two feet. Constructed in 6-foot sections, and available in 100-foot lengths, this containment device is priced at $9.75 per foot. Lower prices are available when booms are purchased in lots exceeding 400 feet in length.

This same boom, with a different label (6-12 Boom), is also available from Worthington Corporation. (See Page 85).

Bulletin and letter received from Metropolitan Petroleum Petrochemicals Company, Inc., Jersey City, New Jersey, October 1969.

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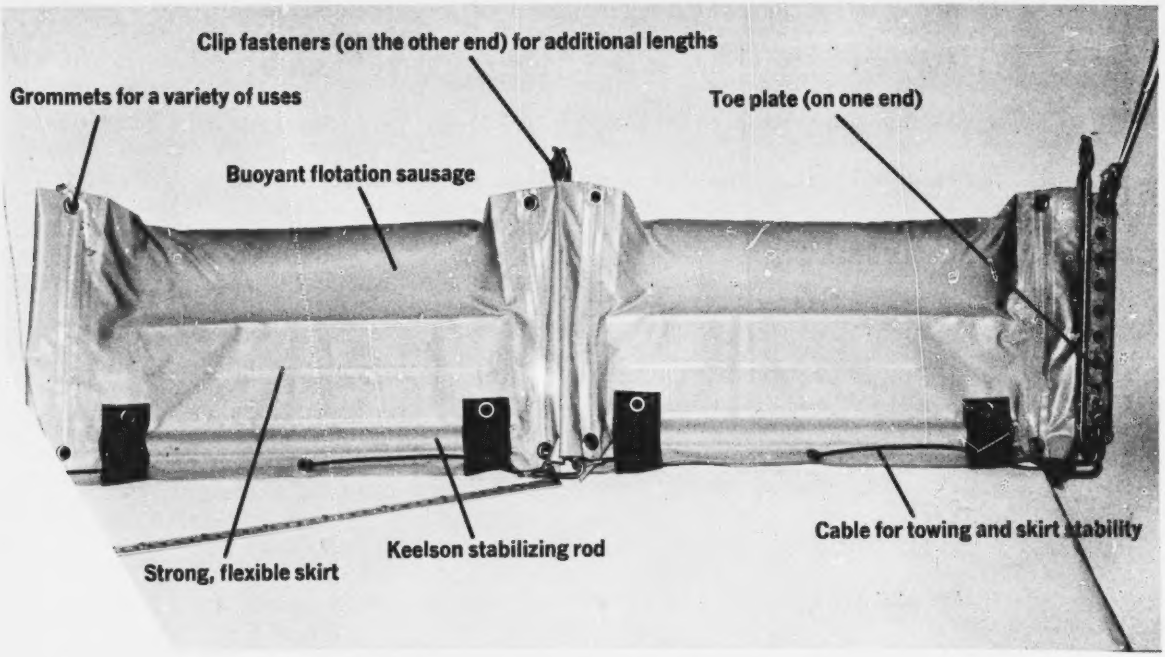
Clip fasteners (on the other end) for additional lengths
Grommets for a variety of uses
Toe plate (on one end)
Buoyant flotation sausage
Cable for towing and skirt stability
Keelson stabilizing rod
Strong, flexible skirt

Figure 10 MP BOOM

MUEHLEISEN BOOM

The oil boom consists of a series of Ethafoam floats from which is suspended a one-foot barrier shield above water and a two-foot skirt below. Manufactured in three-foot high by 100-foot lengths, the barrier is fabricated from a vinyl-nylon material.

Both ends of each 100-foot section are reinforced by doubling the material to form a pocket to insert an aluminum plate; then punching through this reinforced area for the attachment of grommets to prevent tearouts. At each joint where 1,000-foot sections are joined together, a positive lap type connection (full width) is used to prevent oil from escaping through these areas.

The top edge of the barrier shield is semi-rigid construction by reinforcement with PVC pipe and rope hem, with the rope inserted to prevent the top edge from drooping while the boom is floating in either a relaxed position or under tension. The bottom skirt leading edge is lead and chain weighted to maintain the boom in an upright position through a series of perpendicular aluminum rods that are inserted in pockets at the folding parts of the boom.

Each section folds at approximately 3 feet-4 inches on center for the full length of these 100-foot sections to enable stowing in an orderly fashion. The bottom leading edge of the skirt has a rope hem with rope insert and a series of grommets for the attachment of a continuous chain. This chain is attached with lap links in such a manner that the chain's primary function is to relieve the stress on the boom during pulling and installation.

Product bulletins received December 1969 from Muehleisen Manufacturing Company, El Cajon Industrial Park, 1100 North Johnson Avenue, El Cajon, California 92020.

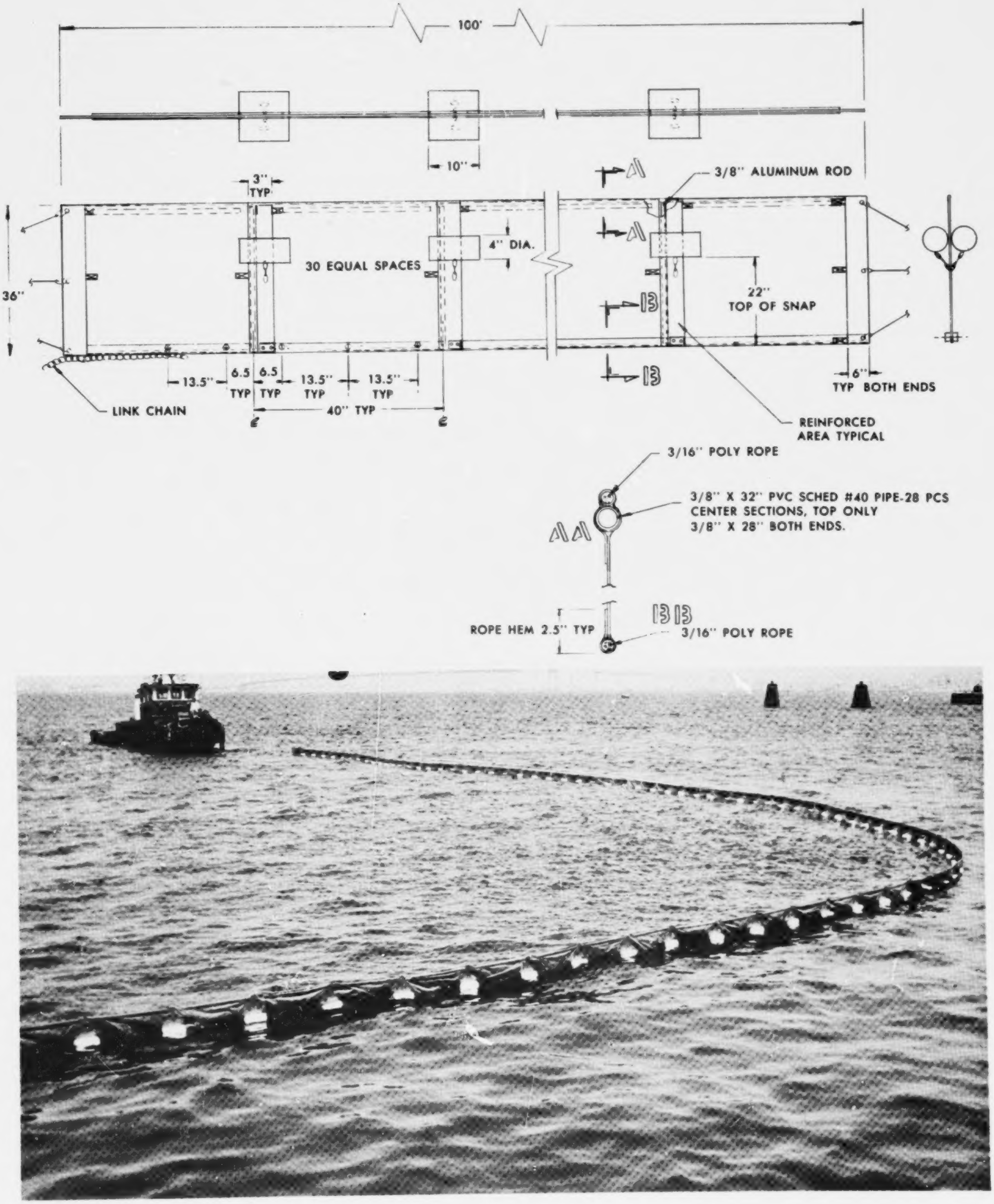
100'
10"
3/8" ALUMINUM ROD
3" TYP
4" DIA.
30 EQUAL SPACES
36"
22" TOP OF SNAP
A
B
13.5"
6.5 TYP
6.5 TYP
13.5" TYP
13.5" TYP
40" TYP
LINK CHAIN
6" TYP BOTH ENDS
REINFORCED AREA TYPICAL
3/16" POLY ROPE
3/8" X 32" PVC SCHED #40 PIPE-28 PCS CENTER SECTIONS, TOP ONLY 3/8" X 28" BOTH ENDS.
AA
BB
ROPE HEM 2.5" TYP
3/16" POLY ROPE

Figure 11
MUEHLEISEN BOOM

OSCARSEAL: HOVER-PLATFORM

The Oscarseal Hover-Platform consists of a series of interconnected "captured air" floats. The standard floats are fabricated from steel plate in lengths of 40 feet. The "Air Skirt" is attached to one side of the float which will form the inner circle. A hinged plate is attached to the opposite side of the "Air Skirt" acting as a depth-shield and keel. Extension curtain sections for high-sea state and locations may be attached to the bottom edge of the shield. Each float has its own blower-air supply system, capable of being powered from a variety of sources.

The linkage of the Oscarseal Containment Systems consist of two clip-links attached to the steel float on the upper edge of the inner-side providing for approximately 3-inches of interval between each two air floats. In addition to this a steel cable is provided to be installed on the top side near the clip-links. It serves both as a safety device for the system, for the service of the embedment anchors, and also for towing purposes.

The "Air Skirt" is made of a puncture resistant textile designed and manufactured to withstand the impact of the sea and the air-

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sea interaction. It is claimed that the skirt material does not absorb water, stays lightweight, is easy to handle even when wet; flash-dries, is rot and mildew resistant, and can be stored wet or dry. It is further claimed that it is easy to clean with a bristle brush, soap and water.

A price quotation will be submitted upon request. The Oscarseal Containment Systems was developed by the Rath Company in a joint venture with Morrison-Knudsen Company, Inc.

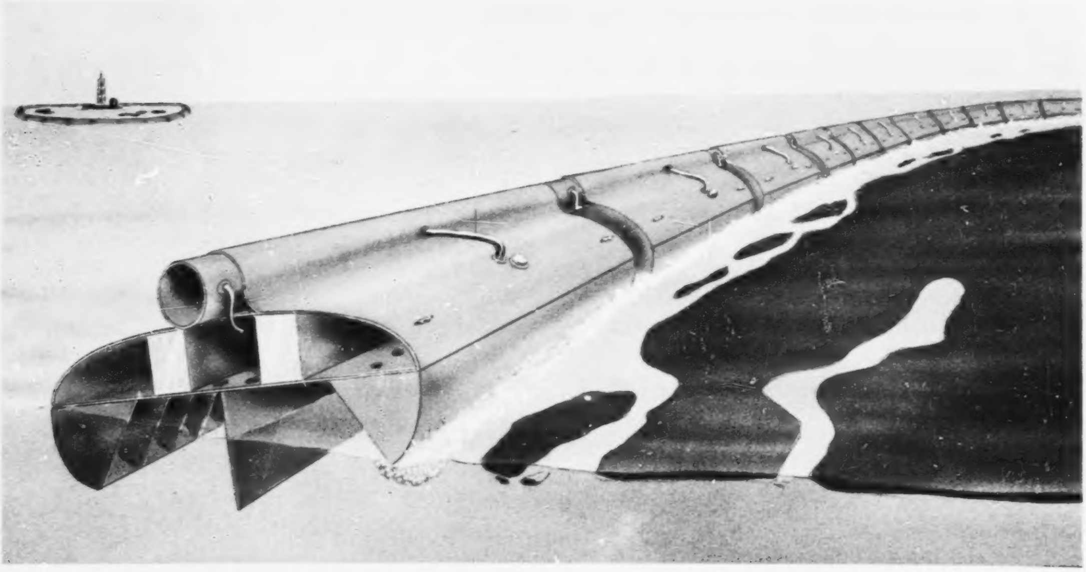


Figure 12 OSCARSEAL HOVER-PLATFORM

Product brochure received in December 1969 from the Rath Company,
P. O. Box 226, La Jolla, California 92037.

OSCARSEAL - STEEL BOOM

Each individual section of the Oscarseal containment boom measures 40 feet in length, is 7 feet wide and weighs approximately 5,000 pounds. Flotation is derived from two longitudinal steel pipes and boxed cross-members. The forward pipe is to be 14 inches in outside diameter and the rear pipe is 12 3/4 inches. Both have wall thicknesses of 3/16-inch and are sealed with welded-on end caps. Two 12 x 12-inch boxed flotation members will be spaced 13 feet inward from the ends of the flotation pipes. In addition, two 24 x 12-inch boxed flotation members are located at each end of the float, both of which are installed on a 45-degree slope to give "lift" to the float when being towed.

A two-foot upright barrier runs the length of the forward 14-inch pipe section. It is constructed with a steel frame and 12-gauge steel face. A rubber seal is attached to the lower edge of this barrier to prevent any passage of an oil slick between the 14-inch flotation pipe and the upright barrier. The barrier itself is hinged to the pipe so it can be folded to facilitate shipment or storage.

Angling downward beneath the 14-inch flotation pipe is a "slope sheet" that is five feet wide and 40 feet long. It has a welded frame of 1 x 1 x 1/8 inch angle steel and a skin-plate of 16-gauge steel. The entire assembly is attached to the 14-inch pipe by hinges, which permit folding for transport or storage, and is also sealed with rubber belting at the point of contact with the flotation pipe. It is suspended beneath the float at a 45-degree angle by adjustable chains.

Running the length of the slope sheet at its low (undersea) end is a 1 1/2 inch-diameter pipe manifold, drilled with a total of 160 holes, each 1/8 inch in diameter and spaced on three inch centers. From these holes, air is emitted to escape upward along the slope sheet, thus giving a rolling action to the water.

Air is supplied at 6-pounds pressure to each unit by means of a 3 HP electric motor that drives a rotary compressor at 1,800 rpm. The compressor delivers 61 cfm of air to the manifold, and by increasing the speed of the motor to 2,400 rpm, can deliver 96 cfm. Motor and compressor are mounted on an angle-iron frame in the center of float.

Electrical power at 440 volts is required to supply a series of Dynamic Oil Boom units. This can be accomplished by a diesel-powered generating unit aboard a service barge or tug.

Each 40-foot float unit is equipped with 1 inch pad eyes and 1-inch shackles for coupling to another unit, thus enabling the boom to be extended to any length. Wire straps may be used on the backside connections in order to permit formation of a desired arc around an oil slick.

Cost of this boom, which is presently not commercially available, is estimated at $40 to $50 per foot.

Product brochure received January 1970 from the Morrison-Knudsen Company, Inc., Box 7808, Boise, Idaho 83707

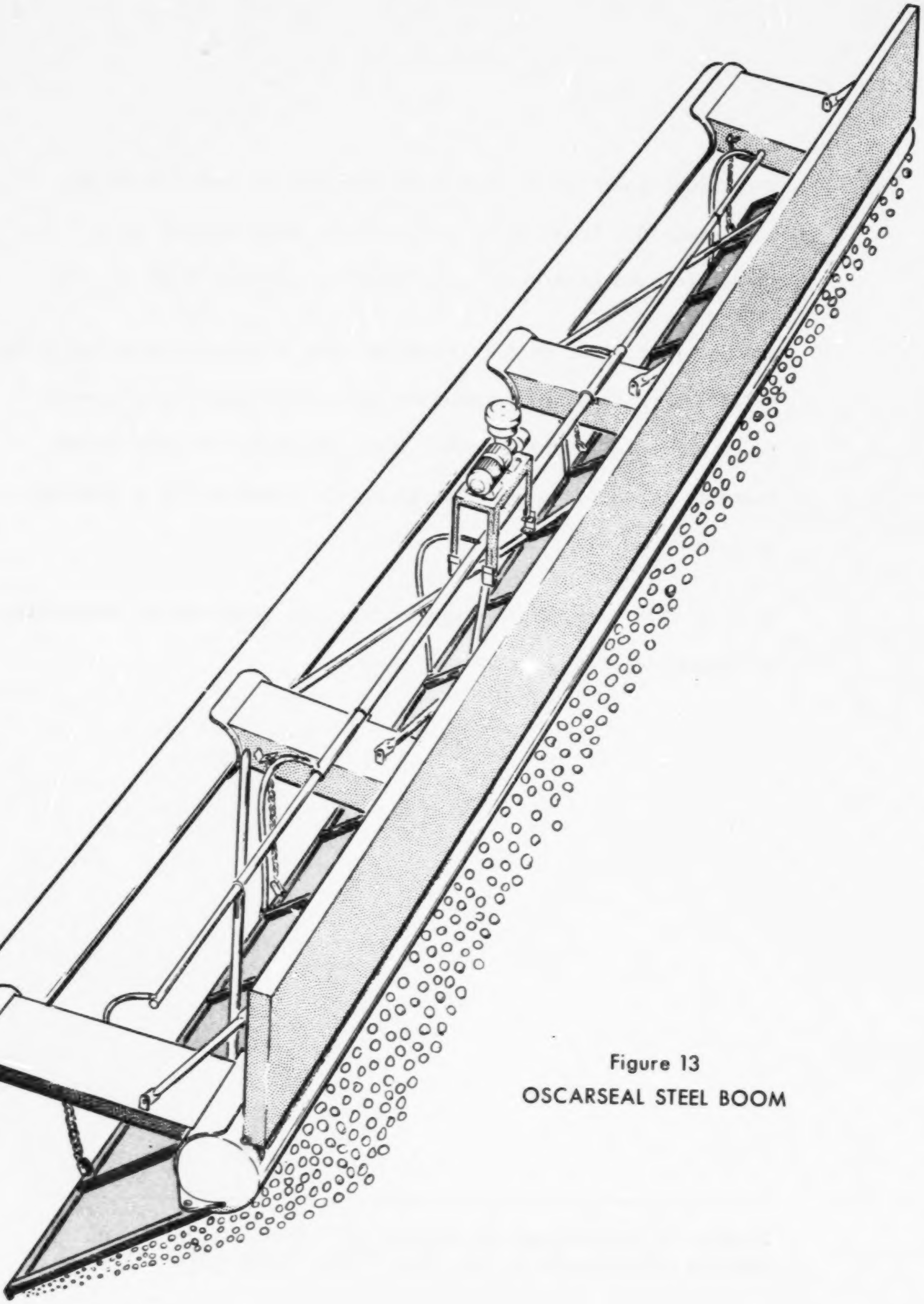


Figure 13
OSCARSEAL STEEL BOOM

RED EEL OIL BOOM

The Red Eel Oil Boom, available from Trelleborg Rubber Company, Inc., New Rochelle, New York, can be assembled on site during oil spill incidents. Sections ready for assembly include a 164-foot length of 23 1/2-inch wide PVC (2-ply); shaped cellular plastic floats; plastic bags for sinkers; seven battens for each 164-foot section; and metal hank couplings to attach each section. Price for each 164-foot section is quoted at $426.40, or $2.60 per foot.

Information supplied by Trelleborg Rubber Company, Inc., P.O. Box 178, 225 Main Street, New Rochelle, New York, 10802, March 1970

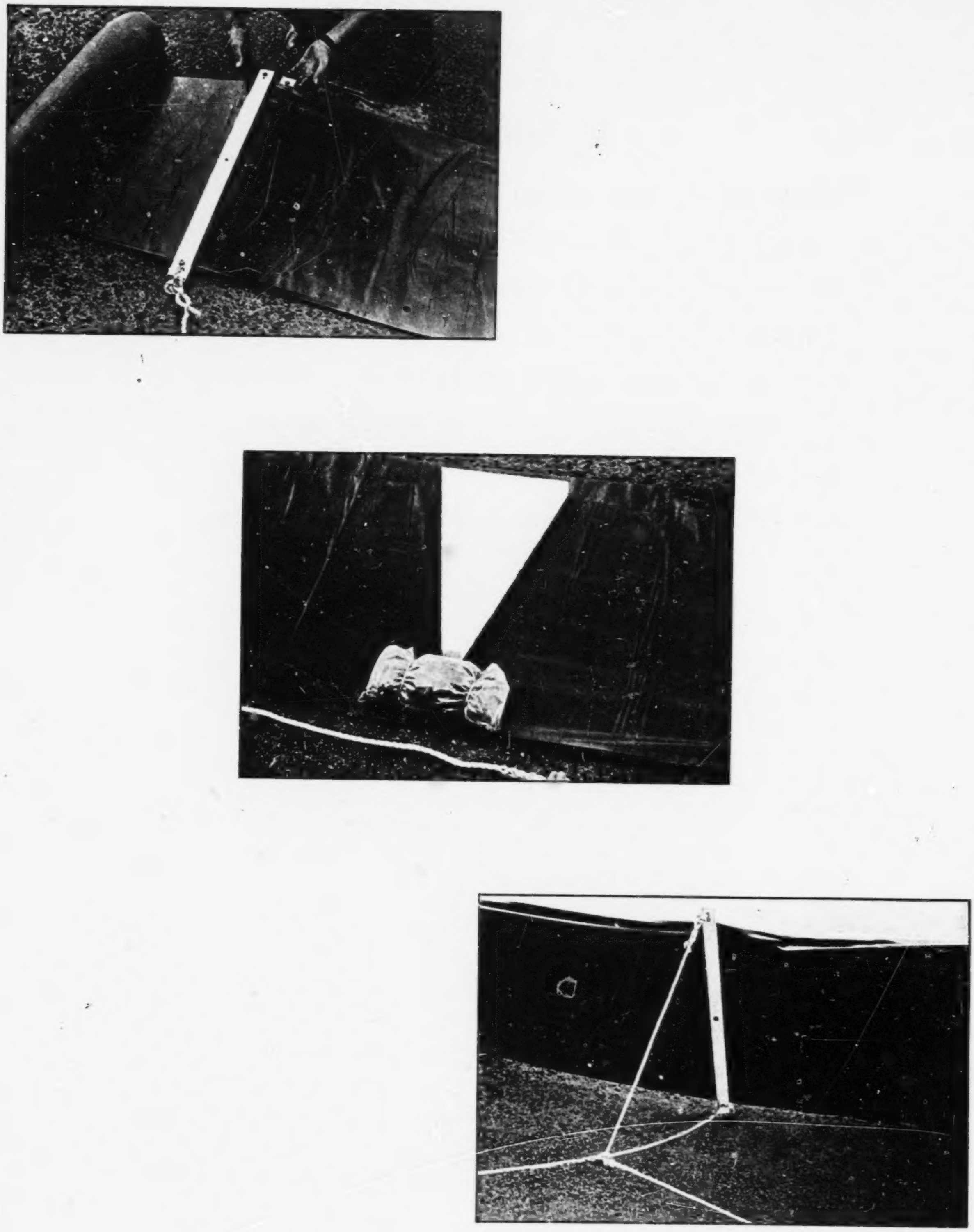


Figure 14 RED EEL BOOM

RETAINER SEAWALL

A light and heavy duty oil containment system has been developed by Environmental Pollution Systems, Inc. The light duty unit consists of two cells, while the heavy duty unit consists of six cells, each made separately and then sealed together to comprise one unit.

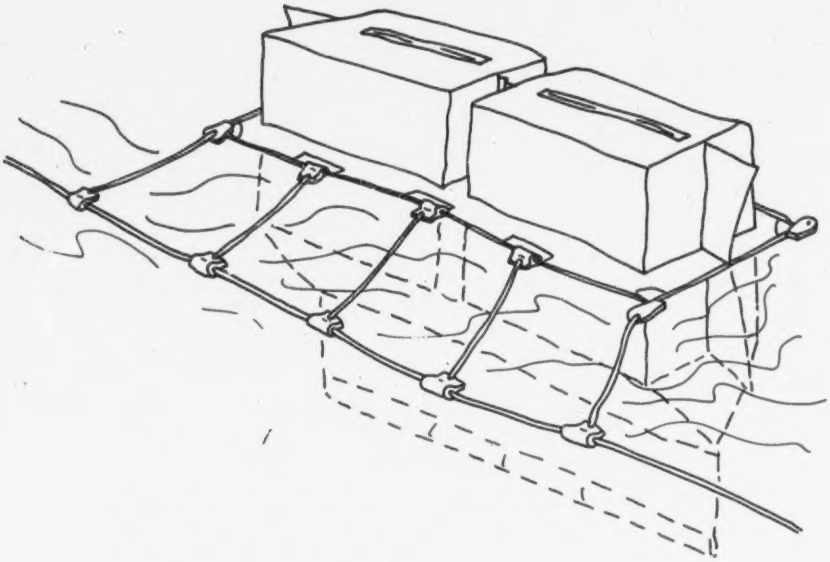
Each cell has a zipper top through which ballast and flotation materials are placed. Two #6 grommets in the bottom of each cell allow movement of water into the cell for additional ballast.

A cell is approximately 11.6 cu. ft. Unit dimensions for the light duty are 2 feet-4 inches wide by 6 feet-11 inches long by 28 inches deep; while the heavy duty unit is 6 feet-2 inches wide. A skirt extends 28 inches below the bottom of the cell giving an overall depth of 4 feet-8 inches. Minimum depth below the water level is 32 inches, thus providing additional protection in rough seas. Skirt design gives a low center of gravity acting as a stabilizer.

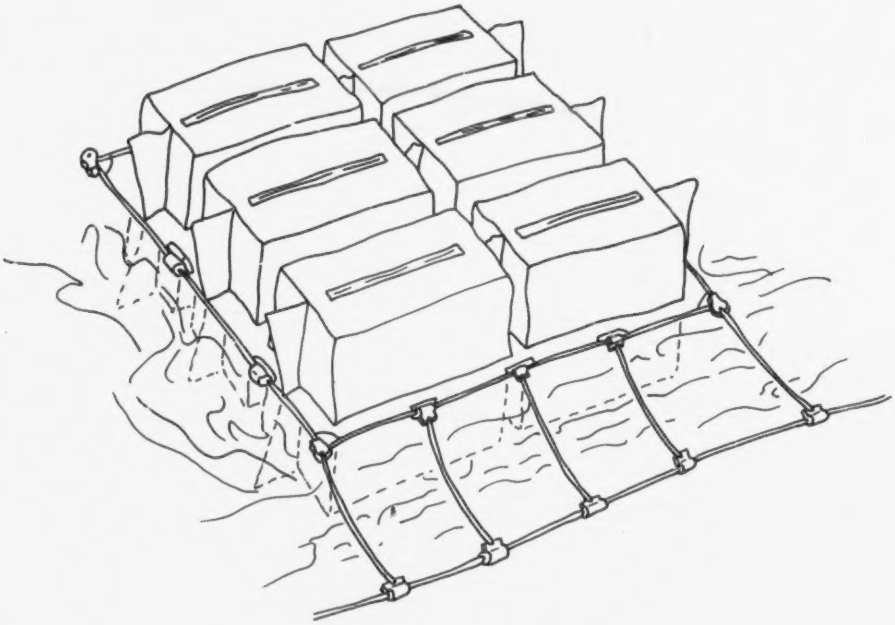
Units are hooked with quick connections to make a wall the desired length. Also, in case of damage, replacement of a single unit is facilitated. The upper and lower fins of each unit are also connected to provide a positive seal for the entire length of the seawall.

Patents are pending on the Retainer Seawall systems. Prices are approximately $20.00 per foot for the light duty and $58.60 per foot for the heavy duty unit, F.O.B. Victoria, Texas.

Product bulletins obtained in December 1969 from Environmental Pollution Systems, Inc., 209 Profit Drive, Victoria, Texas 77901.



LIGHT DUTY UNIT



HEAVY DUTY UNIT

Figure 15

RETAINER SEAWALL

SEA CURTAIN

Sea Curtain, manufactured by Kepner Plastics Fabricators, Inc., Torrance, California, is a relatively large plastic-rubberized oil spill barrier consisting of an upper air or foam-filled flotation chamber, and a lower-hanging skirt. The foam-filled chamber consists of polystyrene beads enclosed in an inner liner. The Sea Curtain is available in standard 20-foot lengths and in four different sizes and types as follows:

Type A - Heavy-duty, off-shore, ocean service boom with foam-filled float 20-inches in diameter and with a 30-inch skirt suspended below. Approximate price is between $10 - $15 per foot.

Type B - Heavy-duty harbor and channel boom with foam-filled float 12-inches in diameter and with an 11-inch skirt below. Approximate price is given as $6 - $9 per foot.

Type C - An emergency service boom with lined-inflatable float 19 inches in diameter and a 32-inch skirt. Price range is between $4 - $6 per foot.

Type D - Light-duty boom with 12-inch inflatable float and an 11-inch skirt. Price range is reported as $2 - $4 per foot.

The Sea Curtain is provided with ballast in the form of a chain running through the bottom of the skirt. Recently,

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Kepner Plastics has started design of booms containing chain ballast on both sides of the skirt with up to 3/8-inch cable being used on the heavy-duty ocean boom. It is possible to add chain ballast onto the offshore boom until the unit weight approaches and even exceeds 10 pounds per running foot of boom. Extremely heavy ballast may be best for severe offshore winds and waves, but until additional data are secured, the company suggests for offshore booms that lesser amounts of ballast in the range of 5 to 7 pounds per foot be employed for ease in handling, towing and installation. The Kepner heavy-duty offshore boom weighs approximately two pounds per foot without ballast. The offshore boom with heavy ballast is belived to be in the cost range of $15 to $17 per foot.

Standard fittings at the ends of each section of the Sea Curtain are reportedly similar to that provided on the Slickbar Boom (given later in this report) although the company is known to be developing new joints providing tighter and more secure connections between sections. The foam-filled boom is apparently recommended by Kepner Plastics over the inflatable-type curtain for durability and longer service upon open waters.

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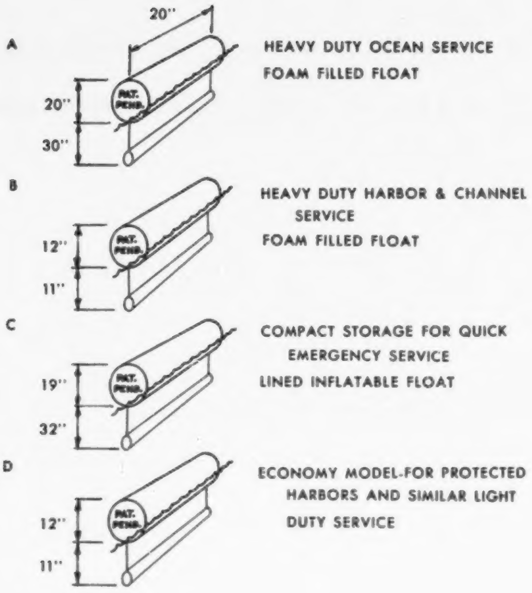
(1) "Study of Equipment and Methods for Removing Oil from Harbor Waters", Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, Washington 99352, Report No. CR 70.001, prepared under Contract N 62399-69-C-0028 for the U.S. Department of the Navy, August 25, 1969.

(2) Product bulletins received from Kepner Plastics Fabricators, Inc., Torrance, California 90510, 1969.

(3) Personal communication with Kepner Plastics Fabricators, Inc., Torrance, California 90510, July and September 1969.


A
20"
20"
30"
PAT. PEND.
HEAVY DUTY OCEAN SERVICE
FOAM FILLED FLOAT
B
12"
11"
PAT. PEND.
HEAVY DUTY HARBOR & CHANNEL SERVICE
FOAM FILLED FLOAT
C
19"
32"
PAT. PEND.
COMPACT STORAGE FOR QUICK EMERGENCY SERVICE
LINED INFLATABLE FLOAT
D
12"
11"
PAT. PEND.
ECONOMY MODEL-FOR PROTECTED HARBORS AND SIMILAR LIGHT DUTY SERVICE

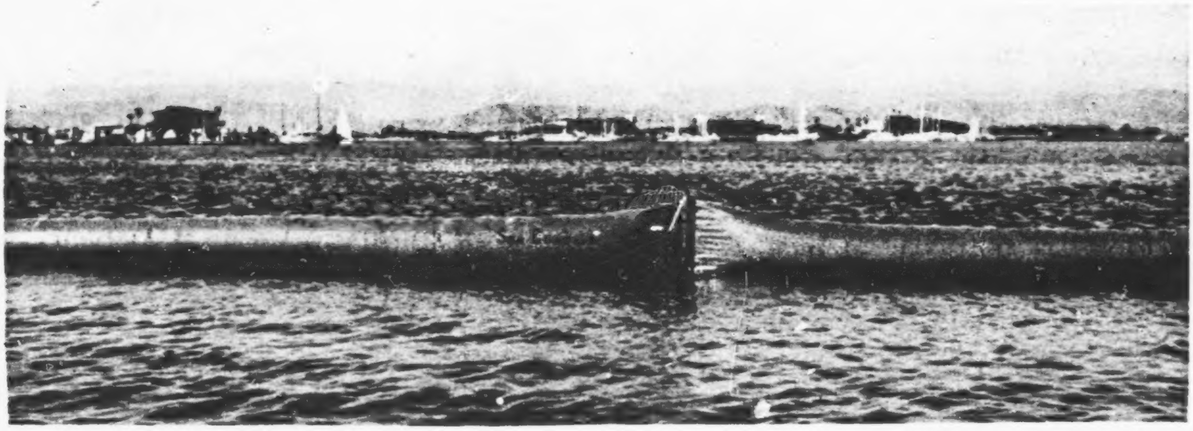


Figure 16
SEA CURTAIN

SEA FENCE

The Sea Fence is an oil spill boom in the experimental-development stage expected soon to be in commercial production by the Aluminum Company of America (ALCOA). The Sea Curtain is made up of rigid vertical sheets of aluminum held together by steel cable, with foamed plastic material for flotation, and neoprene joints providing a flexible seal between the aluminum panels. The boom is fireproof and reportedly capable of being stored onto reels. A prototype model has been tested. However, no further information is currently available concerning the Sea Fence.

"Study of Equipment and Methods for Removing Oil From Harbor Waters", Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, Washington 99352. Report No. CR 70.001, prepared under Contract N 62399-69-C-0028 for the U. S. Department of the Navy, August 25, 1969.

SEALDBOOM

Sealdboom, manufactured by Uniroyal, Inc., Providence, Rhode Island, is a thin-wall barrier made of nylon-rubber. Closed-call polyethylene foam support floats provided on each side of the curtain, are fully-enclosed within the barrier. Vertical stiffeners, which are elastomer-coated spring steel strips, are located 21 inches on center. Available in 30-foot sections, the barrier provided 12-inch freeboard and a 24-inch draft below the waterline.

The curtain is fabricated from "Paracril" coated nylon and is reported to be abrasion-resistant and vulcanized similar to an automobile tire for added strength. The boom, which weighs 3.8 pounds per foot, uses lead weights, spaced 21 inches apart, for ballast. Cost of the Uniroyal barrier is reported as $12.00 per foot.

Information received from Uniroyal, Inc. (U.S. Rubber), Providence, Rhode Island, October 1969.

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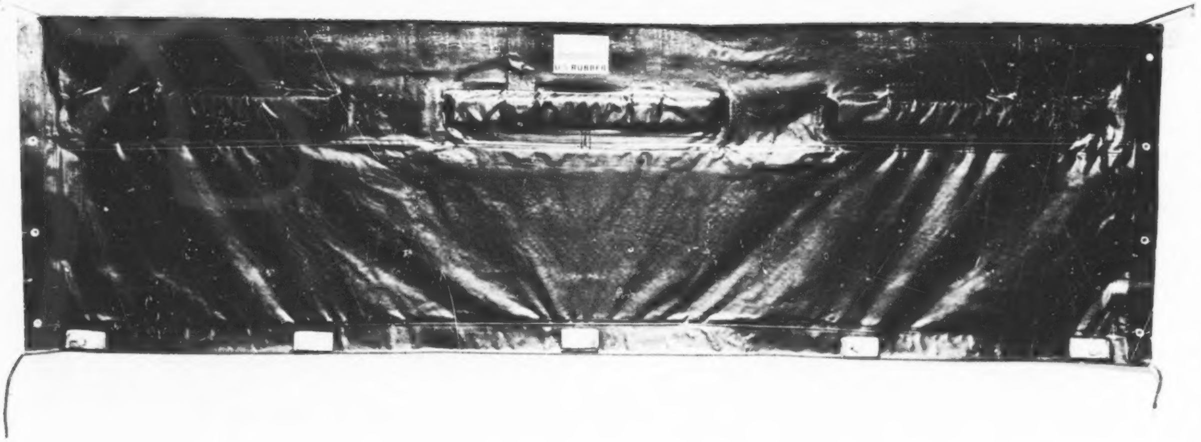


Figure 17 SEALED BOOM

SEA SKIRT

The system consists generally of lengths of inflatable tubing provided with weighted skirts, the widths of which can be changed as conditions require. The tube and integral skirt sections can be stored on a reel in a deflated condition. When needed, the units are inflated as they are being unreeled for deployment into the water. Additional skirt sections can be added during the unreeling and inflating step, or they can be added later. Inflation to a pressure of 0.25 to 0.50 psi is reportedly sufficient to provide buoyancy and still allow flexibility to permit conformance with the water surface.

When deploying, three anchor points are utilized to form an elongated diamond shape, with the long apex being in the downwind or leeward direction. A windward opening can be provided to permit ingress and egress of boats. The windward apexes are held relatively stable by anchor lines, but the leeward apex is free-floating, so that it will not submerge and allow oil to spill over. An oil collecting sump is attached to the leeward apex to permit separation and pumping out of the oil. If the wind direction changes appreciably, either the anchors can be moved or the sump can be moved from one apex to another.

Under circumstances where the 12-inch inflated section is not sufficient, due either to rough seas or a thick accumulation of oil, it is possible to increase the height of the above water barrier by pyramiding the inflated tube units.

No costs are available on this oil boom. This boom is manufactured by Core Laboratories, Box 10185, Dallas, Texas 75201.

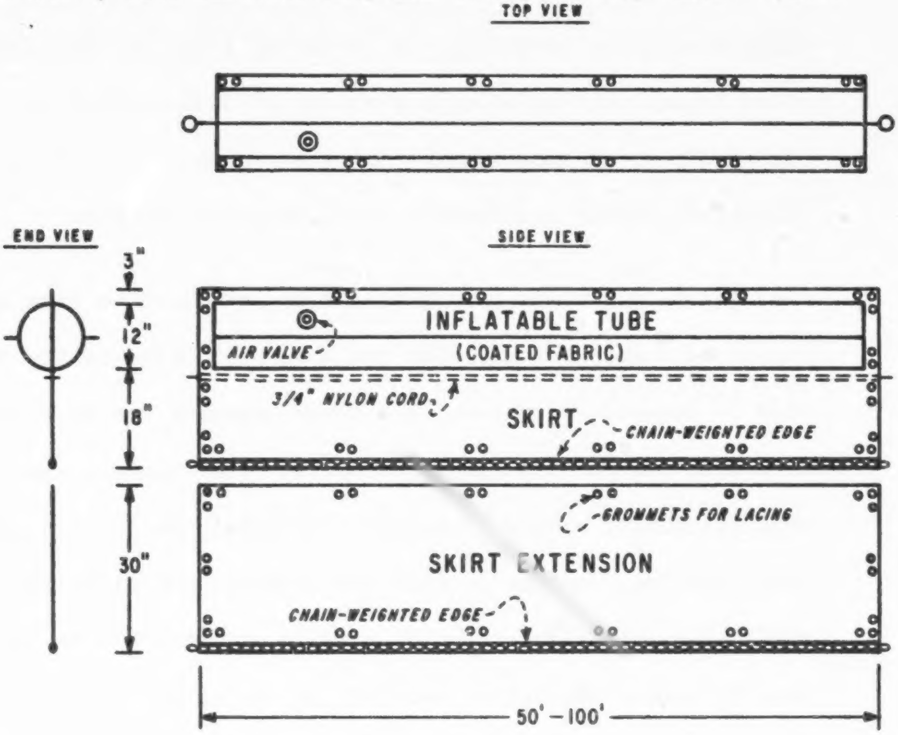

TOP VIEW
END VIEW
SIDE VIEW
3"
12"
18"
30"
INFLATABLE TUBE
(COATED FABRIC)
AIR VALVE
3/4" NYLON CORD
SKIRT
CHAIN-WEIGHTED EDGE
GROMMETS FOR LACING
SKIRT EXTENSION
CHAIN-WEIGHTED EDGE
50'–100'

Figure 18 SEA SKIRT

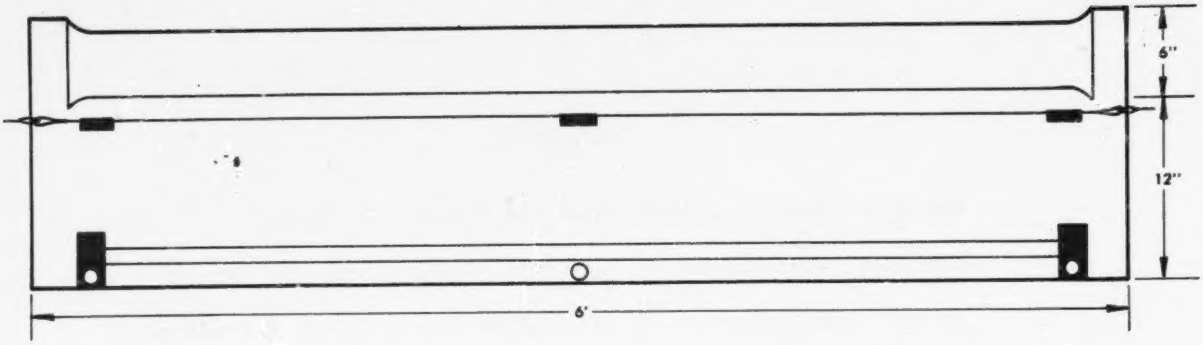
News Release obtained in December 1969 from Lenen & Newell, Inc. Advertising, Wyatt and Williams Division, 19th Floor LTV Tower, Dallas, Texas 75201.

6-12 BOOM

The 6-12 Boom, available from the Pioneer Products Division, Worthington Corporation, Livingston, New Jersey, is the same boom that is offered by Metropolitan Petroleum Petrochemicals Co. (See Page 57).

In addition, Worthington also has available the "Acorn" barrier, which has a flotation chamber of approximately 16 inches, and a skirt of approximately 15 inches. This barrier, which is claimed to be applicable for open sea conditions, weighs 4.4 pounds per foot.

Product bulletin received from Worthington Corporation, Pioneer Products Division, P.O. Box 211, Livingston, New Jersey 07039, 1970



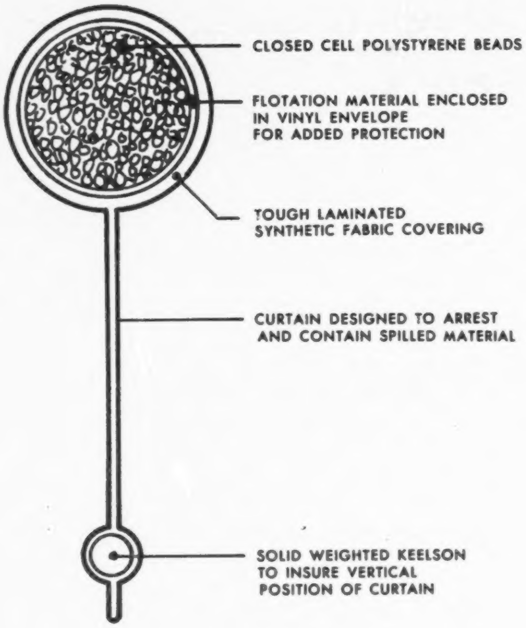

CLOSED CELL POLYSTYRENE BEADS
FLOTATION MATERIAL ENCLOSED IN VINYL ENVELOPE FOR ADDED PROTECTION
TOUGH LAMINATED SYNTHETIC FABRIC COVERING
CURTAIN DESIGNED TO ARREST AND CONTAIN SPILLED MATERIAL
SOLID WEIGHTED KEELSON TO INSURE VERTICAL POSITION OF CURTAIN

Figure 19

6-12 BOOM

SLICKBAR OIL BOOMS

"Slickbar" booms are manufactured by Slickbar, Inc., Westport, Connecticut. They are composed of plastic floats nine-feet long embedded into a plastic fin. The float is additionally secured to the fin by stainless steel straps and rivets at appropriate intervals on the fin. Lead-ballast is riveted directly into the bottom edge of the fin, the amount and spacing of ballast depending upon conditions expected at the use site.

Slickbar booms are manufactured in 4 and 6-inch float diameter sizes, and with fin (skirt) depths ranging from 6 to 24-inches below the float. The booms are also reinforced with 1/4-inch stainless steel cable running directly below the plastic float the full length of the booms, and secured at the float straps and end connectors. Twelve inches of plastic fin abridge each 9-foot float section (6-inches at each end); thus, extending the boom section to 10-feet and providing for a continuous barrier when sections are connected.

Prices for the 4-inch boom, with varying ballast weights, and fin depths from 6 to 18-inches, range from $3.85 to $6.80 per foot. Total system weights for the 4-inch boom vary from 0.74 to 1.77 pounds per foot depending upon the particular boom desired. Prices for the 6-inch boom, with varying ballast weights and fin depths from 6 to 24-inches, range from $5.25 to $12.25 per foot. Total system weights for the 6-inch boom vary from 0.90 to around 3.6 pounds per foot.

Slickbar, Inc. has indicated that their existing oil booms are principally intended for use in harbor areas. A larger and somewhat heavier boom with an 8-inch float, for application in estuarine and offshore waters, is expected to be in production soon.

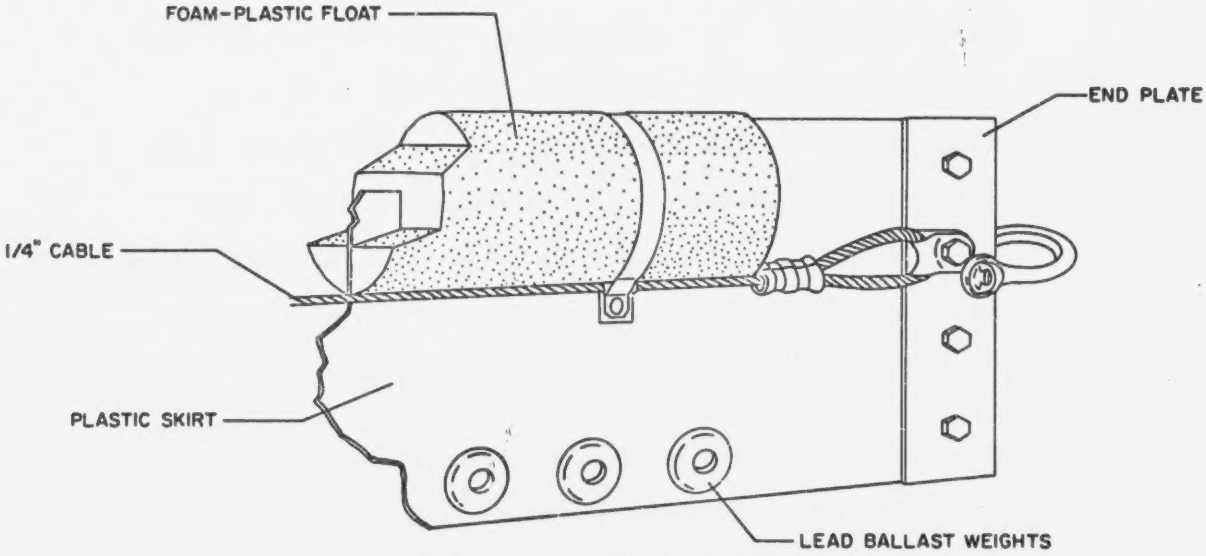


Figure 20 SLICKBAR BOOM

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(1) Product bulletins received from Slickbar, Inc., Westport, Connecticut, 06880, September 1969.

(2) Personal communciation with Slickbar, Inc., September 1969.

SOS BOOMS (SWEDEN)

"SOS Booms", manufactured in Sweden and distributed in the United States, are available in two types: the inflatable emergency boom and the permanent boom of glass-fiber reinforced polyester.

The inflatable emergency boom, suggested for temporary or intermediate use, consists of a circular float section 6-inches in diameter made of PVC plastic, a 14-inch skirt extending downward from the float, and chain ballast provided in the bottom hem of the skirt. This bottom chain is also used in towing the boom. The SOS emergency boom is manufactured in standard lengths of approximately 80 feet. Adjacent sections are joined by vertically-slit rigid PVC tubes and hooks for linking the respective ballast chains.

It is reported that the inflatable emergency boom retains air for long periods of time and that these booms have been in the water for more than two months without need for refilling. The boom may be inflated by means of a motor-driven air compressor, compressed air bottles, etc. Equipment is also available for simultaneously inflating more than one section of the boom at a time. A standard 80-foot length of inflatable emergency boom weighs approximately 29 pounds (unit weight of 0.4 pounds per foot) and had a purchase price in 1967 of $350, East Coast U.S. (i.e., $4.40 per foot).

The SOS permanent boom consists of a 7-inch diameter fiberglass tube filled with urethane foam. Attached to the flotation tube is a nylon-reinforced PVC-coated skirt 18-inches in depth. The SOS permanent boom, available in 10-foot sections, comes equipped with chain ballast fitted into the bottom edge of the skirt. A price of $16.50 per foot, delivered East Coast, U. S., has been reported.

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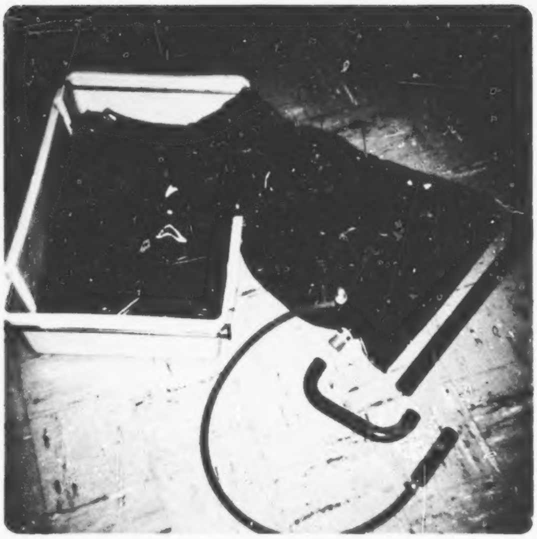
(1) "Study of Equipment and Methods for Removing Oil From Harbor Waters", Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, Washington 99352. Report No. CR 70.001 prepared under Contract N 62399-69-C-0028 for the U. S. Department of the Navy, August 25, 1969.

(2) Product bulletins supplied by Surface Separator Systems, Inc., Baltimore, Maryland 21233, 1968 (products manufactured by Skandinavisk Oljeservice AB, Goteborg, Sweden)

(3) Copy of letters of correspondence from Surface Separator Systems, Inc., to Maryland Port Authority, April 1967.



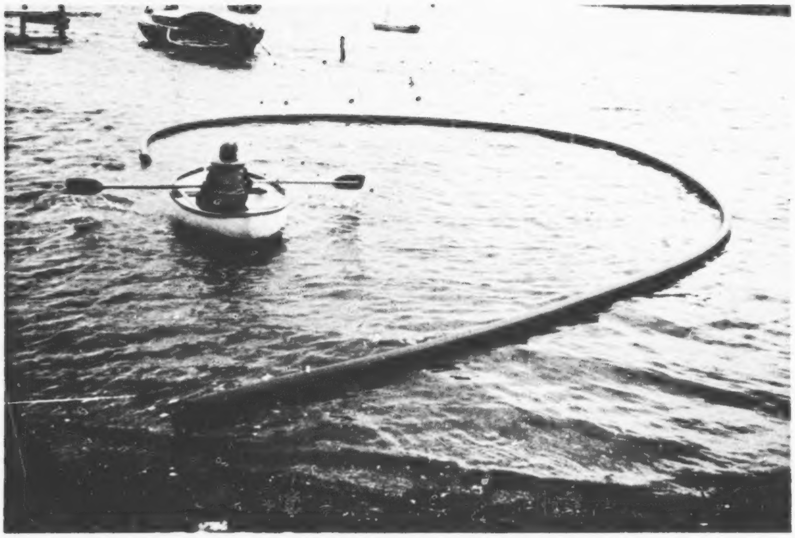


Figure 21 SOS BOOMS

TRANSATLANTIC PLASTICS BOOM

A plastic-filled boom has been developed by Transatlantic Plastics Ltd. It is basically a flat tube divided longitudinally into a continuous, plastic-filled buoyancy bag, and a series of ballast-filled compartments trailing 30 inches under the surface. A plastic straining rope is welded to the length of the boom. Booms made of BXL polyethylene or heavy-gauge flexible PVC have been used already.

"Combating Oil Pollution", Petroleum Times, 71:620, 625-628, April 28, 1967.

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T-T OIL BOOM (NORWAY)

The "T-T" boom is a reasonably-deep plastic rubberized curtain maintained in the vertical position by bottom ballast and floated by means of many individual plastic floats spaced at close intervals attached to both sides of the curtain. The canvas curtain, made of PVC plastic pressed from both sides into nylon cloth, floats in the water with approximately one-foot freeboard and two-feet submersible depth.

Two types of T-T booms are available and different only in the spacing of the plastic floats. The Type 1-98 has floats spaced 3-feet, 4-inches, whereas the Type 2-160 has floats spaced every 2 feet on the curtain. The T-T boom is manufactured in standard lengths of 164-feet (50 meters), is 3-feet deep, and weighs approximately 220 pounds per standard length.

The foam plastic floats are firmly attached by hooks and straps on each side of the curtain. Aluminum rods are sewn into the canvas across the width of the boom (i.e., standing struts) to enable vertical stability of the boom. Lead weights are permanently fixed at appropriate intervals on the lower edge of the

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boom, and increased ballast may be provided by chain threaded through eyelets on the bottom of the curtain extending the full length of the boom. The T-T boom is reportedly highly-flexible in the longitudinal direction, and by means of terylene rope lines running through brass rings fixed on both top and bottom edges of the curtain, the boom can be easily contracted in accordian-like fashion to reduce the encircled area of an oil spill. Tensile strength of the nylon-plastic cloth is reported around 300 pounds per inch. Sections are interconnected by a two-foot overlap of the canvas and appropriate hooks and tie-lines. After use, a standard section may be folded and stored into a 3 foot by 4 foot area.

When the T-T boom is used in towing and for sweeping a sea surface, the ends of the boom may be equipped with "paravanes" for greater stability and ease in handling the boom. The paravanes, made of aluminum, are designed with stable-keel and steering ropes. A pair of paravanes weighs approximately 220 pounds.

Purchase costs for a standard section (164-feet) of T-T boom were reported in May 1969 as $1,110 for the Type 1-98 (i.e., $6.77 per foot), delivered to the East Coast, U.S.; and $1,325 for the Type 2-160 (i.e., $8.08 per foot). A pair of aluminum paravanes were quoted at $720 and Magnet clamps (pair) for attachment of booms to vessels, etc. (weighing 55 pounds) were quoted at $376.

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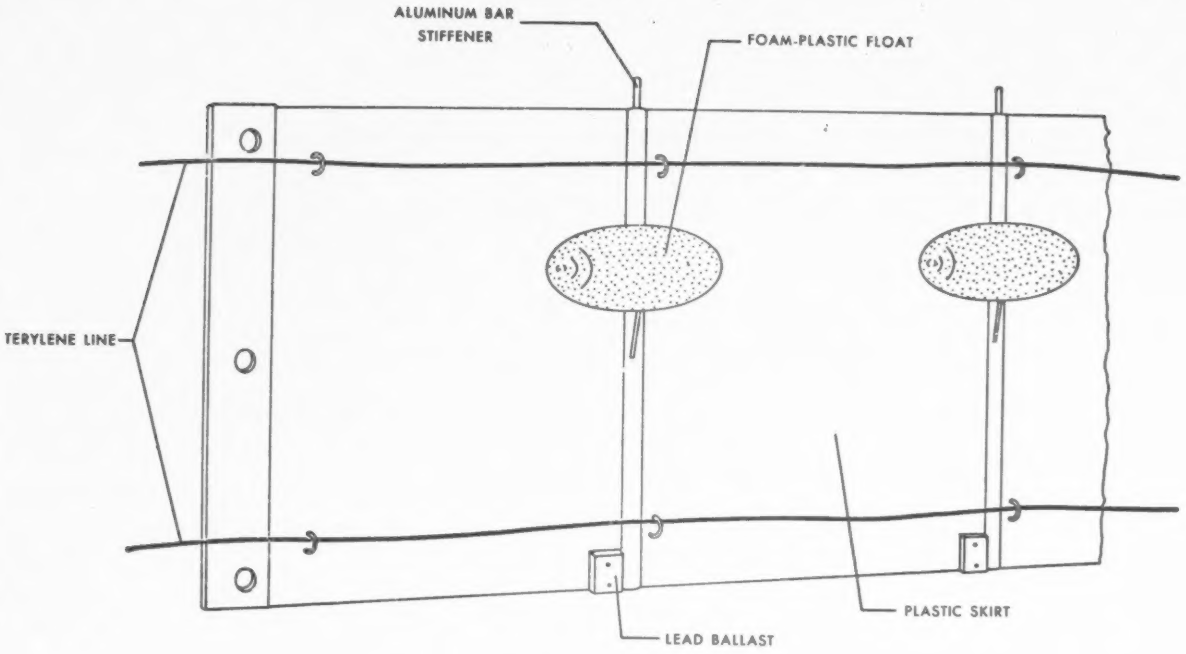
(1) Product bulletin received from Hurum Shipping and Trading Company, Ltd., Montreal, Canada, March 1969 and May 1969.

(2) Personal communication with Hurum Shipping and Trading Company, Ltd., Montreal, Canada, September 1969.


ALUMINUM BAR STIFFENER
FOAM-PLASTIC FLOAT
TERYLENE LINE
PLASTIC SKIRT
LEAD BALLAST

T-T BOOM

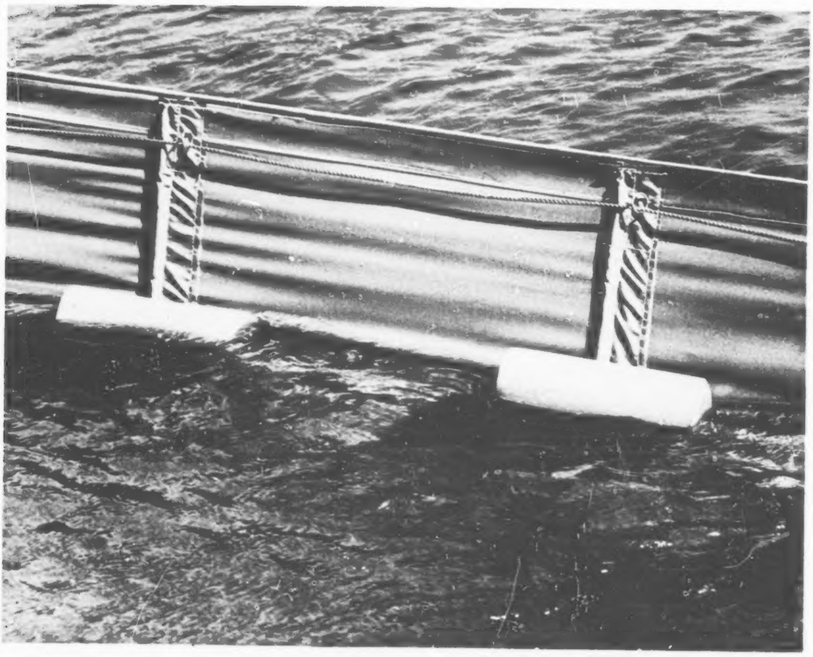


Figure 22
T-T BOOM

WARNE BOOMS (GREAT BRITAIN)

Warne Booms are manufactured by William Warne and Co., Ltd., England, and distributed in the United States by Surface Separator Systems, Inc. of Baltimore, Maryland.

The Warne Booms are heavy-duty booms made of fabric-reinforced synthetic rubber and consisting of an inflatable or plastic filled flotation tube, fabric skirt, and pocket at the bottom edge of the skirt for enclosing chain ballast. Four types of Warne Booms are currently available:

1. Rising and Sinking Boom (Type Z)
2. Inflatable Oil Spillage Boom (Type Y)
3. Polythene Tube-Filled Boom (Type T)
4. Foam-Filled Boom (Type F)

The Rising and Sinking Boom (Type Z) is primarily intended for permanent installation at off-load and on-load terminal facilities and cutout berths where there is heavy vessel traffic. This boom has an 8-inch diameter inflatable chamber, 20-inch skirt and 3-inch tube at the bottom of the curtain for containing chain ballast. Standard sections are 25-feet and 50-feet long, and adjacent sections are connected by pin-hinge joints. A permanent air supply is required for this installation. An air line runs the full length of the boom and release valves are incorporated into each boom section to avoid over-pressurizing. Although the main line air pressure is maintained around 40 psi, the pressure within the flotation chamber approximates only 1.5 psi. Prices recently quoted for the Type Z boom are $440 for the 25-foot length and $750 for the 50-foot length (i.e., $15.00 to $17.40 per foot).

The Inflatable Oil Spillage Boom (Type Y) is similar to the Rising and Sinking Boom. Whereas this boom is available with either an 8 or 16-inch diameter flotation chamber — the skirt, the 3-inch weighing tube, and other appurtenances and connections are identical to those employed for the Type Z boom above. The inflatable barriers may be rolled-up when not in use, or the hinged joints permit the boom to be folded concertina-wise in an enclosed area of the harbor away from vessel traffic. Spring-loaded non-return air valves connecting adjoining sections of the boom ensure that the entire length of barrier will not lose buoyancy if one section fails; yet the same air system permits the complete boom to be inflated from a common point.

The inflatable Warne Booms have been used for controlling the spread of petroleum fires, and in some cases, water hoses have been added across the top of the boom making it possible to spray a water curtain over the entire length of the barrier. Recent price quotations for the Type Y Warne Boom are given as follows: 8-inch float, 25-ft. section - $445; 8-inch float, 50-ft. section - $755; 16-inch float, 25-ft. section - $585; 16-inch float, 50-ft. section - $940. The above price range is $15.10 to $23.40 per foot.

The Polythene Tube-Filled Boom (Type T) is different from the inflatable booms in that the flotation chamber is tightly filled with 2-inch diameter polythene tubes which are sealed or crimped at 2-ft. intervals and at the ends of the boom section. The Type T boom is intended for use in strong tidal conditions and rough waters. The Type T boom is similar in outer configuration, but reportedly more flexible and durable than the inflatable barriers. The polythene tube-filled boom, constructed of synthetic rubber and reinforced with plastic fabric, has a 20-inch weighted skirt and is available with either 8 or 16-inch flotation chambers, and in standard lengths of 25 and 50 feet. Because of the nature of the Type T boom, it is less vulnerable to failure than inflatable booms used under the same conditions. This boom is relatively expensive and latest prices for East Coast, U.S. delivery are as follows: 8-inch float, 25-ft. section - $595; 8-inch float, 50-ft. section - $975; 16-inch float, 25-ft. section - $900; 16-inch float, 50-ft. section - $1,525. The above price range is $19.50 to $36.00 per foot.

Except for the differences in the type of flotation chamber, the neoprene-coated, plastic foam-filled boom (Type F), is essentially the same, including its application potential, as the Type T Boom. Prices for this boom are in the same general area as the Type T barrier.

The Warne booms are relatively heavy and their unit weights are in the range of 6.0 to 8.5 pounds per foot. The majority of weight is centered in the 5/8-inch chain ballast inserted in the bottom of the curtain of most booms. This chain has a unit weight of 4.3 pounds per foot.

The company also specifies that any type of boom must receive proper and continuous maintenance to operate satisfactorily over long periods, and for its permanent installation, the company recommends weekly inspection and servicing if necessary. If an oil boom is held within the water for considerable time, maintenance and routine cleaning of the boom become very important. Without cleaning, it has been shown that accumulated marine growths can greatly limit the effectiveness of a boom, besides causing serious damage to the boom itself.

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(1) Personal communication with Surface Separator Systems, Inc., Baltimore, Maryland 21233, October 1969.

(2) Product bulletins of Warne and Co., Ltd., England, received from Surface Separator Systems, Inc., Baltimore, Maryland 21233, 1968.

(3) Product bulletins received from Surface Separator Systems, Inc., Baltimore, Maryland 21233, 1968.

(4) "Floating Oil Spill Booms - Their Use for Counteracting Spillages", Dock & Harbor Authority, Vol. 42, No. 498, April, 1962.

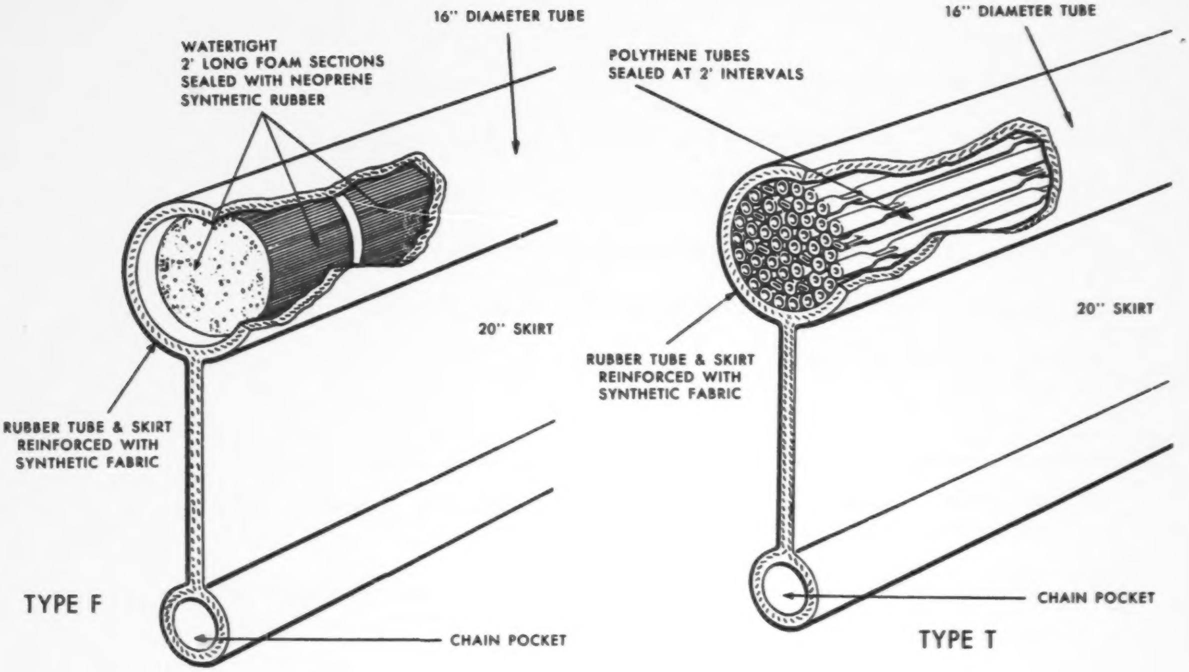
(5) "Removal of Oil from Harbor Waters", Scott, A. L. and Gifford, S. E., Technical Note N-964, Naval Civil Engineering Laboratory, Port Hueneme, California 93041, February 1968.

(6) "Containing and Removing of Oil Spillage from Water Surfaces", Cornelessin, J., MPD Division, Paper C-9, Pollution Abatement Conference, The Hague, 1963.

(7) "Oil Spillage Booms", Petroleum Times, 69, No. 1775, August 20, 1965.

(8) Inter-Office Memo by U. S. Corps of Engineers, Hydraulic Design Branch, August 3, 1967.

(9) "Study of Equipment and Methods for Removing Oil from Harbor Waters", Battelle Memorial Institute, Pacific Northwest Laboratories, Report No. CR 70.001 Prepared under Contract N 62399-69-C-0028 for the U. S. Department of the Navy, Richland, Washington 99352, August 25, 1969.


16" DIAMETER TUBE
WATERTIGHT
2' LONG FOAM SECTIONS
SEALED WITH NEOPRENE
SYNTHETIC RUBBER
20" SKIRT
RUBBER TUBE & SKIRT
REINFORCED WITH
SYNTHETIC FABRIC
CHAIN POCKET
16" DIAMETER TUBE
POLYTHENE TUBES
SEALED AT 2' INTERVALS
20" SKIRT
RUBBER TUBE & SKIRT
REINFORCED WITH
SYNTHETIC FABRIC
CHAIN POCKET

TYPE F

TYPE T

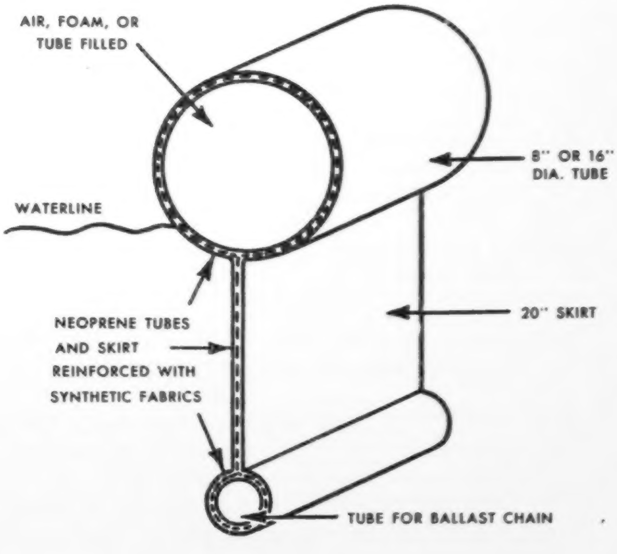

AIR, FOAM, OR
TUBE FILLED
8" OR 16"
DIA. TUBE
WATERLINE
20" SKIRT
NEOPRENE TUBES
AND SKIRT
REINFORCED WITH
SYNTHETIC FABRICS
TUBE FOR BALLAST CHAIN

Figure 23
WARNE BOOMS

WATER POLLUTION CONTROLS BOOM

Water Pollution Controls, Inc. has developed a 48-inch diameter inflatable device which is stored as a thin plastic "ribbon", attached on a reel, and designed for compact stowage on ships, helicopters and drilling rigs. The boom can be retrieved after use and eliminates the need for skirt attachment.

Deployment around the spill periphery is made from a helicopter or small craft using a reel to unload an evacuated ribbon from an anchored and marked point of beginning. The purpose of stringing the material flat is to make possible the accommodation of several thousand feet of containment equipment on a spool of reasonable diameter and weight. After making turns for a closure back to the original point (around buoyant floats), inflation of the evacuated tube begins at a single point into a valve.

Inflation of the ribbon is accomplished by use of a small pump discharging through a venturi, taking sea water into its suction, and air into the venturi inlet. Gauges provide the unit volume ratio (air to water) desired to meet the sea condition and determine what portion of the tube will serve as the underflow skirt or surface trap.

This design eliminates the need for a skirt attachment. Inflation of 4,000 linear feet of 48-inch diameter tubing reportedly can be accomplished in approximately 30 minutes, with a pump delivering a one-to-one air to water ratio through the venturi.

The tubing can be modular, and therefore, is capable of being expanded or contracted as need requires. After the oil has been removed and the need for containment is over, the ribbon can be retrieved.

The patent is pending on this containment device.

Product bulletin received in December 1969 from Water Pollution Controls, Inc., 2035 Lemoine Avenue, Fort Lee, New Jersey 07024.

MULTIPURPOSE BOOMS

SUMMARY TABLE

MULTIPURPOSE BOOMS

Boom	Stage of Development	Cost $/Ft.	Manufacturer
1. ICI Oil Absorbing Boom	In Production	$6.75 - 7.45	ICI Fibres Ltd. Harrogate Yorkshire, England
2. Roscoff Heavy and Light-Weight Booms	Used at Torrey Canyon Spill	Unknown	Marine Biological Laboratory Roscoff North Brittany, France
3. Sea Serpent	Under Development	Unknown	Johns-Manville Co. 22 East 40th Street New York, New York 10016
4. Skimmer Boom	Patent Pending	Unknown	E. P. Hall FWPCA Washington, D.C. 20242

ICI OIL ABSORBING BOOM (GREAT BRITAIN)

The ICI boom, fabricated by ICI Fibres, Ltd., Yorkshire, England, has been designed to serve both an oil spill barrier and absorbent boom for collecting floating oils. The main feature of the ICI boom is the heavy oil-absorbing skirt or curtain, which consists of a 2-foot wide quilt of polypropylene fibre wrapped within "ulstron" polypropylene netting, and mounted on a "spunstron" polypropylene support rope. The boom (and skirt) is fitted with alternative floats depending upon site conditions; otherwise the polypropylene quilted skirt may be used without floats for absorbing oils in quiet waters. It is reported the skirt can absorb oils upwards of six times its own weight.

The skirt is made up in individual sections 25-feet long. The fibrous polypropylene is loosely packed in the netting amounting to about 7 pounds absorbent material per running foot of the boom. The netting is oversewn with synthetic twine at 18-inch intervals to form pockets of fiber and give the appearance of a large quilted blanket. By itself, the polypropylene quilt will float on water, but it is normal practice to provide chain ballast on the skirt of one pound per foot or greater. The polypropylene skirt, 2-feet deep by approximately 3-inches thick, is supported on the polypropylene "spunstron" headrope, which is one-inch in diameter and has a minimum breaking strength of 7.5 tons.

Various floats suggested for the ICI polypropylene skirt include:

1. Polyethylene or propathane semi-rigid tubing having one-quarter inch wall. This tubing is heat-sealed on the ends and adjacent lengths are attached by flexible couplings. The float is attached to the headrope on the polypropylene skirt by straps wound around the circumference of the float. This type of float is reported relatively durable and can withstand a high degree of abrasion.

2. Twelve-inch diameter spiral-reinforced flexible ducting produced from PVC-coated nylon fabric. The ducting is filled with polystyrene and attached to the skirt headrope by grommetted flaps on the ducting.

3. Polyurethane coated nylon fabric containing an inflatable inner tube made of PVC with independent inflation nozzles. This type of float is provided with flanges for attachment to the skirt headrope and/or secured by straps around the float and headrope.

The above floats are provided in standard lengths varying from 20 to 150-feet. Sections of polypropylene skirt are linked by eye splices and shackles on the headrope, together with twine interlacing between the skirts. Total weight of the ICI oil absorbing boom is in the range of 7.5 - 9.0 pounds per foot. Price quotations were given in 1967 as \$4.70 per foot for the polypropylene skirt alone, and \$6.75 - \$7.45 per foot for the complete boom assembly including one of the three alternative floats described above.

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(1) "Cleaning up the Oil", Paper published in Petroleum Magazine; however volume, numbers and date of this article are not known.

(2) "New Boom Absorbs Oil", Chemistry and Industry, p. 632, April 22, 1967.

(3) General information release, ICI Fibres Ltd., Harrogate, Yorkshire, England.

ROSCOFF HEAVY AND LIGHT-WEIGHT BOOMS (FRANCE)

Of the large mass of oil which escaped from the Torrey Canyon in March 1967, part of it in weathered form or in the highly-emulsified chocolate mousse form, finally reached the coast of North Brittany, France, between Roscoff and the Ile de Batz around mid to late April 1967. The Marine Biological Laboratory at Roscoff provided considerable assistance in shoreline defense, particularly in design and construction of oil spill barriers. Two types of booms developed for use during this period are described below.

The first of these was a heavy boom comprised of blocks of expanded polyurethane (6.5 ft. by 1 ft. by 1 ft.) surrounded by great amounts of straw and overwrapped by a parcel of rubber sheeting 39 feet long. The exterior of the boom was covered by 0.3-inch mesh seine netting and a 24-inch ballasted skirt was suspended from the boom. The barrier was strengthened by 1/4-inch nylon rope encircling the boom at 20-inch intervals and by a 1/2-inch nylon rope running the length of the boom. The ends of adjacent sections of boom were overlapped 3 - 6 feet and firmly bound together by 1/2-inch ropes. The heavy boom has reasonably good flotation and provides 8 - 12 inches

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freeboard above water. However, the weight and bulkiness of this boom created problems in handling and deployment. It was reported that sections of heavy boom, 330 feet long and 2.3 feet in diameter, have an approximate weight of 7,000 pounds and require at least 100 men to lift these sections onto the shore. It was also found the net wrapping was not strong enough to withstand abrasion from the shore bottom. Further problems were encountered in attempts to moor the boom against the strong tidal current mainly because anchor blocks were too light and there was an insufficient supply on hand. Subsequent change was made in the above boom whereby the sections were reduced to 93 feet in length, weighing 2,400 pounds, and the boom was covered by double-woven jute sacking to increase its strength against tearing.

The light boom was a smaller version of the boom described above with the purpose of being deployed in more confined areas and for combating superficial films of oil or small patches remaining after the large oil masses had passed. The expanded polyurethane blocks were of smaller size around 20-inches by 6-inches by 4-inches, lesser quantities of straw were used, and the boom sections were reduced to 93 feet in length with an approximate diameter of 8 inches. The small barrier was strengthened by 1/4-inch sisal rope encircling the boom at 12 - 16 inch intervals and longitudinal pull was taken by 1/2-inch nylon rope. The boom was covered with jute sacking and a short skirt was attached and also made of jute. The buoyancy of the small boom was relatively good, but this boom provided only 2 inches freeboard, thereby limiting its use to calm waters. Despite reduction in size, it was found for proper mooring, this boom required 90 - 220 pound anchors every 15 - 16 feet.

Other observations were made concerning both types of booms. Straw was used in construction of the booms because of low cost, availability and adsorptive properties. The chocolate mousse emulsion was reportedly broken down by the hydrophobic properties of the straw causing the oils to agglutinate. The boom skirts made of netting and subsequently weighed, were found effective in strong currents only if liberal amounts of straw were spread on the waters directly in front of the boom before arrival of the oil slick. Although the heavy boom appeared capable of giving good protection against moderate oil slicks, a better system of mooring is advised. This boom, in offering considerable resistance against strong waves and currents, requires great weight in anchoring. It was also reported that in bad weather both booms "suffered", presumably due to the battering action of strong waves and currents.

"How Roscoff Won the Torrey Canyon Battle", Cabioch, L. and Lacassagne, M., The Dock Harbour Authority, Vol. I, No. 583, May 1969.

SEA SERPENT

"Sea Serpent" is an absorbent product currently in the final testing phases by the Johns-Manville Company. The product may be described as sausages or bundles of oil-absorbent material contained in a polypropylene mesh netting. The sausages may be tied together into the form of an oil boom or applied in discrete bundles onto an oily-water surface and later retrieved.

The absorbent material is a preprocessed rayon fiber in a polypropylene rayon fiber. The manufacturer reports the fiber will absorb approximately 6 - 16 times its own weight in crude oil. If so desired, the oil-saturated bundles may be incinerated, and manufacturing objectives indicate complete combustion is possible. The absorbent sausage, when commercially made available, will likely have an approximate size of 8-feet long by 16-inches in diameter and weigh about 30 pounds per section. A nylon or plastic-type rope is strung through the sausages to couple the units together for towing purposes or for stringing an oil boom.

Information received from Johns-Manville Company, Manville, New Jersey 08835, 1969.

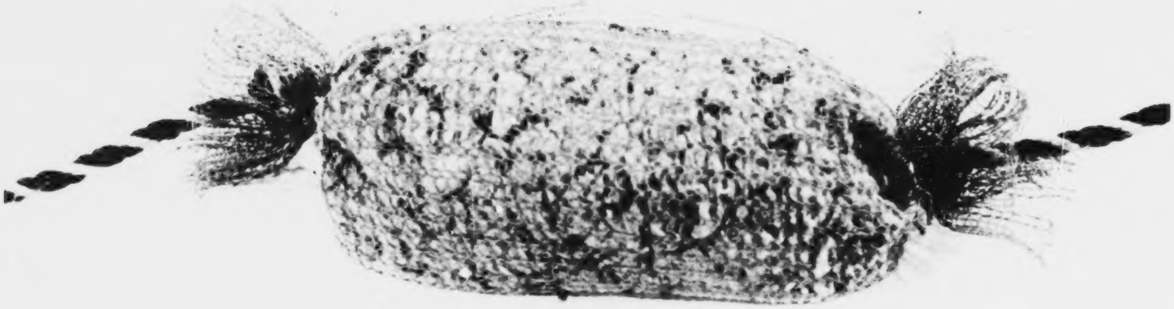

Figure 24 SEA SERPENT

SKIMMER BOOM

The Skimmer Boom is a concept described in a patent application whereby a skimming trough is embodied as an integral function within a floating boom for the purpose of containing and collecting floating oil. It is envisioned the collected oils or oily-water mixtures are subsequently conveyed to recovery facilities for eventual disposal and/or reuse.

The Skimmer Boom provides three functions: a skimming tube or section for oil capture; a flotation section to properly float the boom on the water; and a weight section to provide integrity and stability of the boom.

The skimming section of the boom allows for entry of floating oils through a series of slots, over a weir, or other means, into the trough or skimming tube. The floating section is specified as being filled with air, cellular material or other appropriate means. The patent description indicates that the size and shape of the skimmer slots, and the flotation and weighting materials may be varied into a wide range of configurations without altering the basic concept.

Report of Invention on Skimming Boom for Floating Oil, Hall, E.P., Radamacher, J.M., and Biglane, K.E., U. S. Department of the Interior, FWPCA, December 15, 1967.

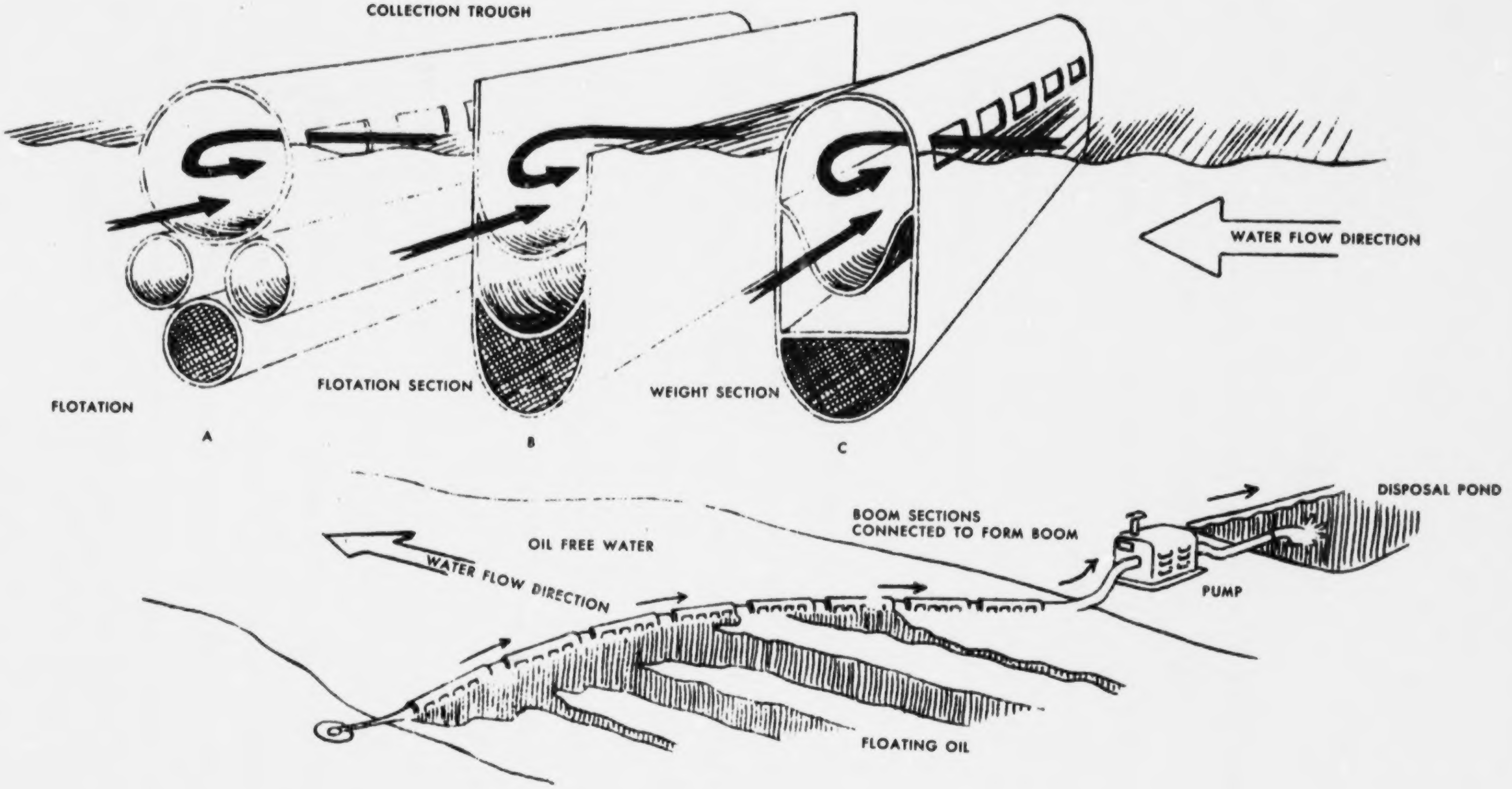
COLLECTION TROUGH
WATER FLOW DIRECTION
FLOTATION
FLOTATION SECTION
WEIGHT SECTION
A
B
C
BOOM SECTIONS
CONNECTED TO FORM BOOM
DISPOSAL POND
OIL FREE WATER
WATER FLOW DIRECTION
PUMP
FLOATING OIL

Figure 25
SKIMMER BOOM

IMPROVISED BOOMS

SUMMARY TABLE

IMPROVISED BOOMS

Type of Boom	Location Where it was Used
1. Cork-Filled Boom	Norfolk, Virginia
2. Cork-Float Boom	Port Hueneme, California
3. Fire Hose Boom	Quiescent Waters
4. Puerto Rican Boom	*Ocean Eagle* Oil Spill
5. Rubber Bladder Boom	Helford River, Great Britain
6. Rubber Tire Boom	*Torrey Canyon* Oil Spill
7. Steel Pipe Boom	Philadelphia, Pennsylvania
8. U. S. Navy Boom	Long Beach, California; Chevron Spill, 1970
9. Wooden Float Boom	Pearl Harbor, Hawaii
10. Wooden Timber Boom	Quiescent Waters
11. Wooden V-Boom	Peros Gyiroc, France

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CORK FILLED BOOM

The U. S. Navy facilities at Norfolk, Virginia have employed a homemade boom of granular cork enclosed within 6-inch diameter neoprene fabric tubing. The flotation cylinder is attached to a 2-inch submersible skirt with sufficient ballast affixed to the skirt. Standard sections are 10-feet long and the boom is reported easy to handle and clean. Although the Norfolk cork-filled boom is relatively stiff, it functions suitably in certain harbor waters. No further information is available concerning this boom.

"Removal of Oil From Harbor Waters", Scott, A. L. and Gifford, S. E., Technical Note N-964, Naval Civil Engineering Laboratory, Port Hueneme, California, February 1968.

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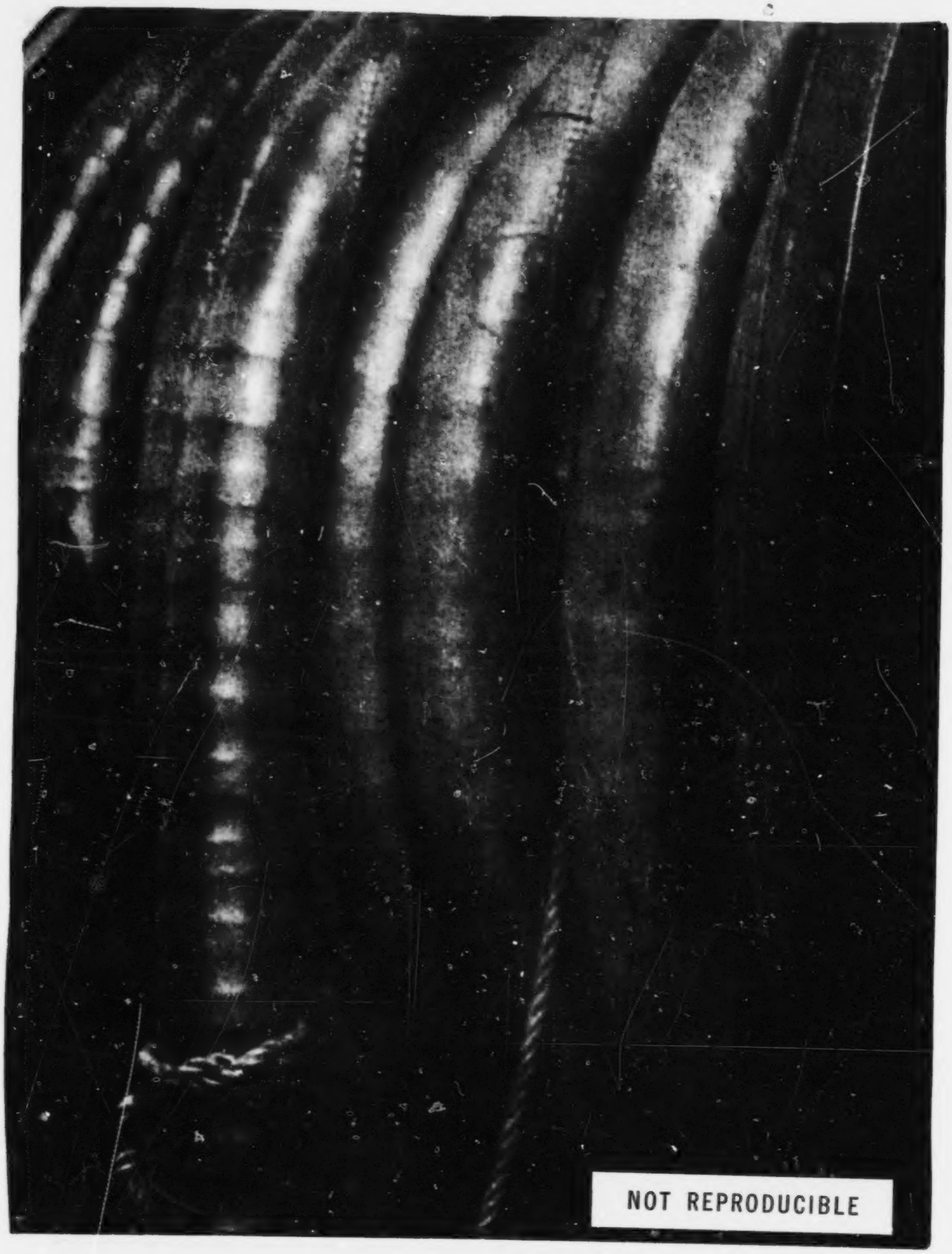
NOT REPRODUCIBLE

Figure 26 POLYVINYL COVERED 6-INCH DIAMETER CORK FLOAT BOOM ON 8-FOOT DIAMETER REEL

CORK FLOAT BOOMS

A U.S. Navy report indicates that cork float booms are used for combating oil spills in harbors and other protected areas. One type of cork float boom is made up of a series of cork discs 6-inches in diameter by 2-inches thick, and 3-inches in diameter by 1-inch thick, strung alternately onto a 3/8-inch diameter cable. The cable may be made of polyvinyl-coated steel or bronze. The cork floats are then suitably enclosed inside a polyvinyl or canvas cover. On occasion the cover is perforated to permit water to enter and cause the boom to float lower in the water. This type of boom is available in 50-foot sections and normally is unskirted.

The cork float boom is adaptable for being rolled onto large reels for storage and transportation. For use in somewhat rougher waters, a one-piece polyvinyl (presumably slip-on) cover and skirt is also available. The flexibility of the cork float boom reportedly permits the boom to follow the water profile very closely. Nevertheless, the absence of a skirt would cause loss of oil under the boom even in relatively quiescent waters and a submersible curtain is advised.

These booms are reported quite durable, easily cleaned and handled especially when powered reels are employed. Estimated costs for the above cork float boom is around $6 per foot.

"Removal of Oil From Harbor Waters", Scott, A. L. and Gifford, S. E., Technical Note N-964, Naval Civil Engineering Laboratory, Port Hueneme, California, February, 1968.

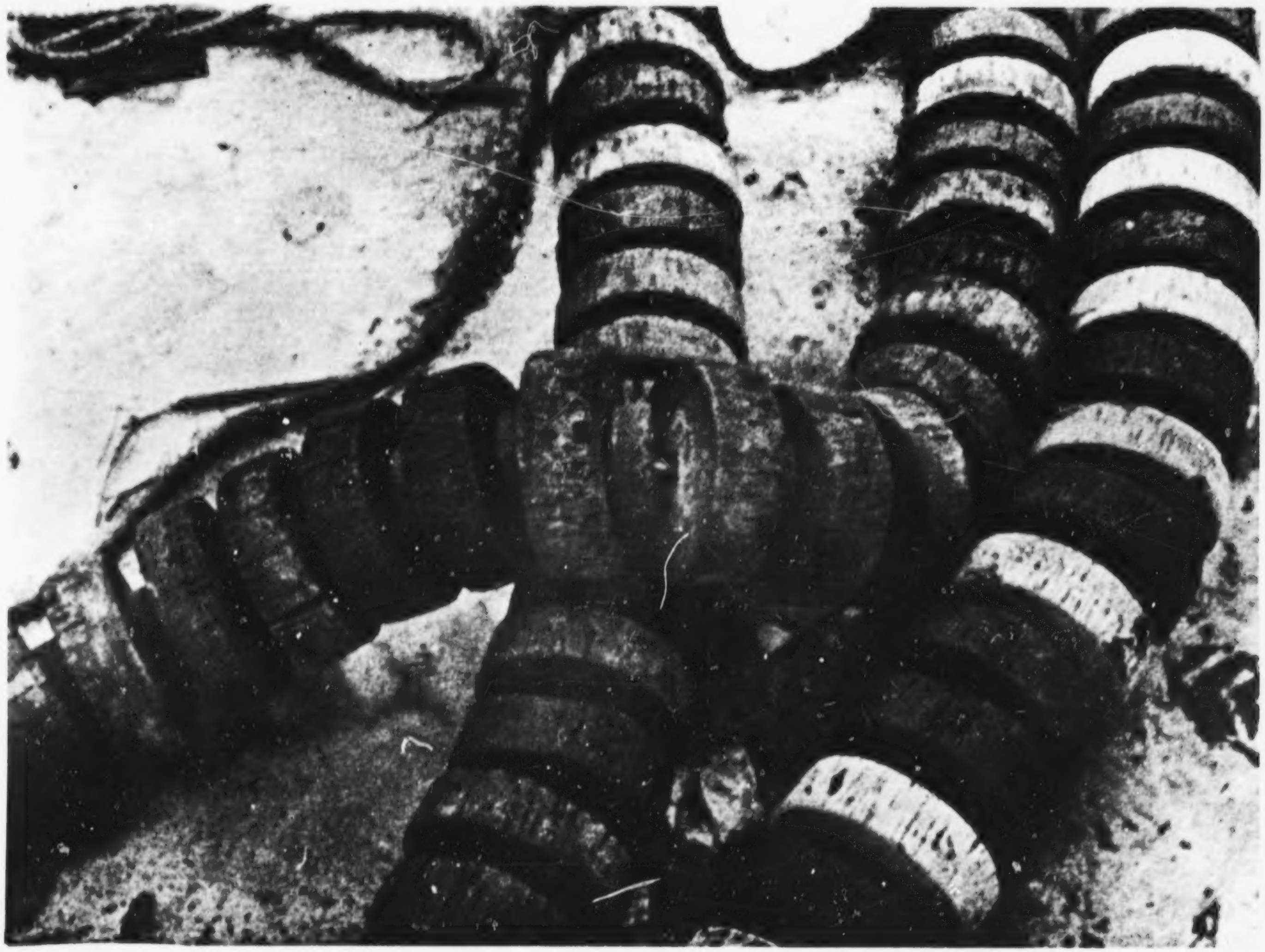

Figure 27 SIX-INCH DIAMETER CORK BOOM
SHOWING ARRANGEMENT OF FLOATS TO PROVIDE FLEXIBILITY

FIRE HOSE BOOM

Readily-available fire hose inflated for use as an oil boom has been deployed in many port and harbor areas for containing oil spills. The normal couplings are removed from the hose and replaced with plastic or aluminum inserts for connecting the various lengths of hose. Metal caps and air valve fittings are provided on the ends of the hose, and the sections are then inflated with air.

This type of boom is reported easy to tow and clean. Afterwards, the sections are deflated and rolled up for compact storage. Because of its relative stiffness and small diameter, floating oils will sweep over and under this boom when the water surface is other than calm. The fire hose has limited use.

"Removal of Oil From Harbor Waters", Scott, A. L. and Gifford, S. E., Technical Note N-964, Naval Civil Engineering Laboratory, Port Hueneme, California 93041, February 1968.

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PUERTO RICAN BOOM

A large floating boom was fabricated by the Puerto Rico Department of Public Works following the sinking of the "Ocean Eagle" in the entrance to San Juan Harbor on March 3, 1968. Two 55-gallon drums were firmly secured onto each side of 4-foot by 8-foot sections of 5/8-inch marine plywood. A canvas curtain was then attached to the bottom edge of the plywood extending 40-inches below the boom and a 1 1/2-inch steel rod was inserted in the curtain serving as ballast. Heavy canvas was also provided between successive sections of plywood to seal the sections and a heavy steel cable was strung continuously and fastened across the uppermost part of the plywood sections for longitudinal strength in the boom. In many respects, this boom is quite similar to the U. S. Navy - Long Beach (California) boom described elsewhere in this report.

A total of 588-feet of continuous boom was fabricated and subsequently placed in the harbor waters on March 20, 1968. However, by this time it was reported the oil pollution problem had materially subsided.

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(1) Preliminary Report of March 13-21, 1968 concerning the Ocean Eagle Tanker, San Juan, Puerto Rico, unpublished, FWPCA, Southeast Regional Office, Atlanta, Georgia, 1968.

(2) Trip Report of April 2, 1968 concerning the Ocean Eagle Tanker, San Juan, Puerto Rico, Inter-Office Memo, FWPCA, Southeast Regional Office, Atlanta, Georgia, 1968.

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RUBBER BLADDER BOOM (GREAT BRITAIN)

Following the Torrey Canyon, a rubberized-bladder oil boom was tested at the mouth of the Helford River in Great Britain. This boom consisted of a number of rubber bladders approximately 18-inches in diameter by 15-feet long fastened together by ropes and anchored at the ends of the sections. The bladders were filled with air for flotation. Whereas no actual data were available, it appeared that the boom would be adaptable only for quiescent waters. Indication was given that short period waves of 2 feet or more and excessive water current could cause the boom to break or otherwise cause floating oils to be carried under the boom.

Inter-Office Memo by U. S. Corps of Engineers, Hydraulic Design Branch, August 3, 1967.

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RUBBER TIRE BOOM (FRANCE)

During the Torrey Canyon, the Roscoff Laboratories in North Brittany, France also conceived a boom system consisting of abundant amounts of foam plastic wrapped with straw and burlap encased in used automobile tires on both sides and around the bottom of the boom. The tires served to protect the burlap covering and to reduce waves splashing over the top of the boom. It was also visualized that fish netting would be suspended from the bottom tires to give proper depth to the boom. The rubber tire boom was to be anchored with 80 pound weights spaced at 20-meters along the barrier and with anchors weighing one ton each spaced every 100-meters. There is no information to indicate whether this boom was fabricated and eventually used.

Inter-Office Memo by U. S. Corps of Engineers, Hydraulic Design Branch, August 3, 1967.

STEEL PIPE BOOM

A make-shift steel pipe boom has been used across the mouth of a river in the Philadelphia area serving as both an oil and debris barrier. The boom is made up of a continuous length of 8-inch pipe about 80-feet long welded shut on both ends. One end has a horizontal ring which encircles a pile and the boom rides up and down the pile as the tide varies. The other end has a cable loop which allows the gate to be opened and vessels to pass through. The steel pipe boom used mainly as a debris barrier is reported relatively inexpensive, durable, and maintenance-free. As an oil boom, this device would appear effective only for quiet water conditions.

"Removal of Oil From Harbor Waters", Scott, A. L. and Gifford, S. E., Technical Note N-964, Naval Civil Engineering Laboratory, Port Hueneme, California 93041, February 1968.

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U. S. NAVY - LONG BEACH (CALIFORNIA) BOOM

The U. S. Navy at their Naval Shipyard in Long Beach, California, has fabricated and tested a sturdy oil boom made up of heavy plywood sections (serving as the vertical curtain) supported and floated by a series of 55-gallon drums strapped to both sides of the plywood sections along the full length of the boom.

The individual boom units consist of 4-foot by 8-foot plywood sheets (4 ft. vertically and 8 ft. horizontally) onto which four 55-gallon drums are strapped - two drums on each side. The individual units are joined together with two sheets of nylon cloth impregnated with vinyl ("Fasilon"). This nylon cloth is also used for the bottom skirt. Half-inch wire ropes are firmly attached to the outer periphery of each drum and the painters run the full length of the boom on both sides of the barrier. These wire guides provide suitable tensile strength in towing and mooring the boom, particuarly in relieving stress and tear in the nylon-vinyl end connections. The 24-inch bottom skirt is weighted or ballasted with approximately 50 pounds of sand or scrap material per 8-foot section.

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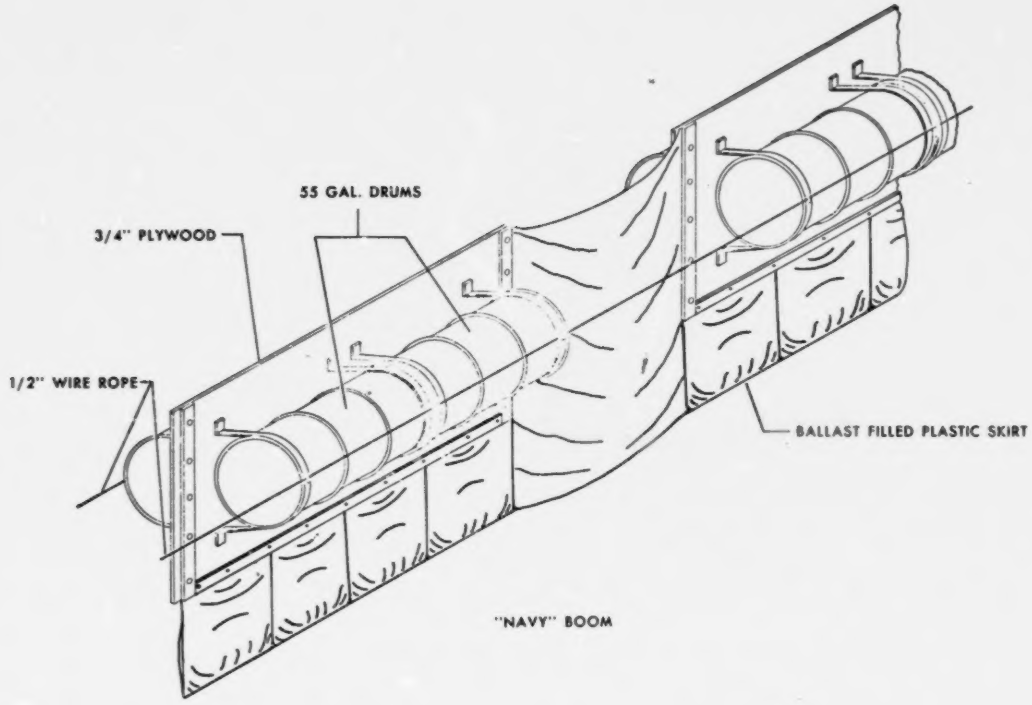
55 GAL. DRUMS
3/4" PLYWOOD
1/2" WIRE ROPE
BALLAST FILLED PLASTIC SKIRT
"NAVY" BOOM

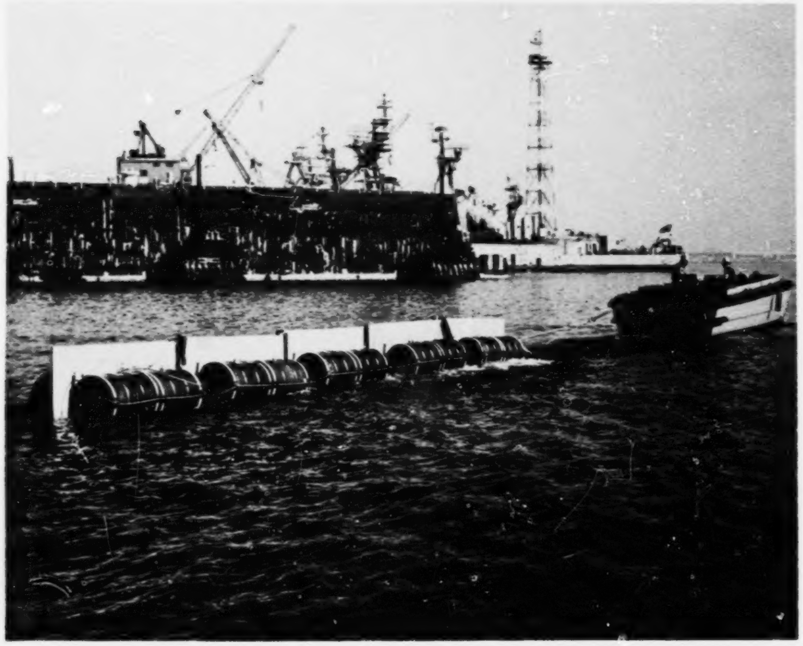

Figure 28
NAVY BOOM

WOODEN FLOAT BOOM

A wooden float boom has been previously used in Pearl Harbor. It consists of short compact hollow wooden floats 6-inches square by 36-inches long, interconnected by heavy waterproof canvas held onto the ends of the floats by 1/8-inch copper wire. The wooden floats are made from 1 1/4-inch redwood (often scrap lumber), grooved and nailed together, with a cap plug at each end of the float to give additional buoyancy. Several of these booms are used alternately so that the wood may dry adequately between uses, thereby minimizing damage by marine growths. The wooden float boom is reported relatively inexpensive, light-weight and easily deployed.

"Removal of Oil From Harbor Waters", Scott, A. L. and Gifford, S. E., Technical Note N-964, Naval Civil Engineering Laboratory, Port Hueneme, California 93041, February 1968.

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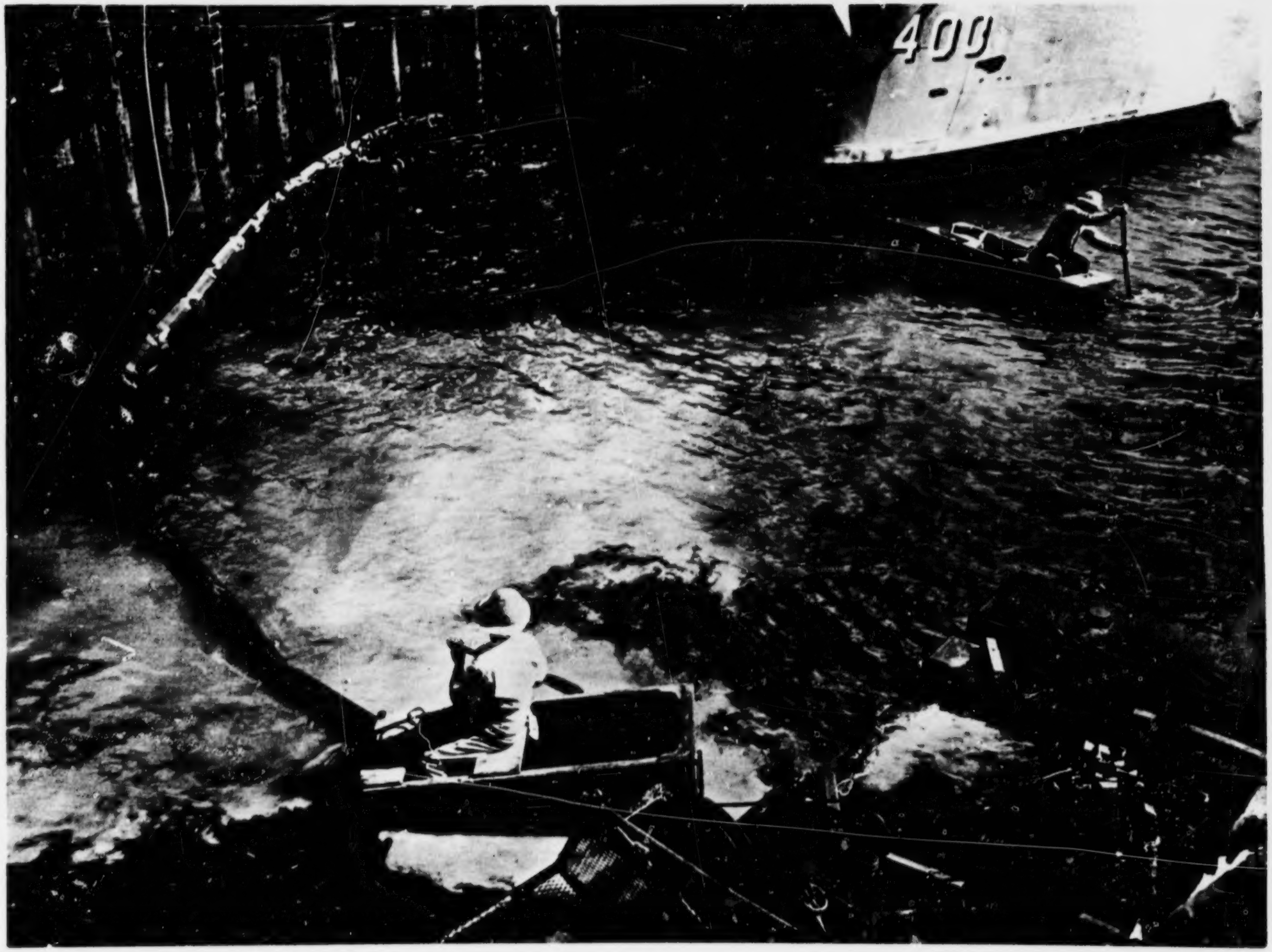

Figure 29 PEARL HARBOR WOOD FLOAT BOOM

WOODEN TIMBER BOOMS

Wooden timber booms may be assembled by joining together used wooden timbers or telephone poles end-to-end, and wrapping the ends with heavy canvas, burlap or other suitable material to preclude oil leakage between the joints. To provide increased strength and integrity over a long wooden boom, a steel cable is strung continuously over the length of the boom and fastened to each wooden section at two or more points.

Advantages of the wooden timber booms are their relative simplicity and comparatively low cost. Because of its rigidity, the timber boom will not closely follow the contour of a water surface, which is subject to wind and wave action. Therefore, the timber boom is considered only appropriate in relatively quiet waters.

"Study of Equipment and Methods for Removing Oil From Harbor Waters", Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, Washington 99352. Report No. CR 70.001 prepared under Contract N 62399-69-C-0028 for the U. S. Department of the Navy, August 25, 1969.

WOODEN V-BOOM (FRANCE)

In attempts to preclude large amounts of crude oil from the Torrey Canyon flowing into the harbor at Peros Gyiroc in France, a V-shaped wooden boom was anchored to two jetties spanning the harbor entrance. A pair of 1 1/2 by 12-inch planks were nailed together in the shape of a trough. It was hoped short-period waves would spill oil into the trough and the oil could be recovered by pumping from both ends of the trough. The boom remained in place under quiet water conditions but broke apart under subsequent wave action. The trough was not effective in removing oils from the harbor waters.

Inter-Office-Memo by U. S. Corps of Engineers, Hydraulic Design Branch, August 3, 1967.

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AIR CURTAINS

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AIR CURTAINS

Air Barriers for Oil Slick Containment

The air barrier (air curtain) represents, in certain cases, an alternative method of containing or confining spilled oils within a given area, and also preventing floating materials from entry into high-use waterfront areas. A perforated pipe is laid on the river or harbor bottom and compressed air is forced through the line. The air delivery pipe may also be suspended at some depth above the river bottom depending upon local conditions. A curtain of rising air bubbles produces an upward current which upon reaching the free surface, spreads laterally in opposite directions. The artifically-induced currents generated by the air curtain are designed to counter the normal surface currents prevalent in the body of water, thus confining floating pollutants within the desired boundaries. The air barrier has distinct advantages over the physical oil booms since vessel traffic may pass through the control area without hindrance; however, it also has certain disadvantages. The Standard Oil Company (New Jersey)

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reports that:

> "The capacity of a pneumatic barrier is limited by both environmental and economic considerations. The natural current of the water effects the rising air plume, by causing it to lean over. If the plume is leaned over more than 30 degrees from the position it would assume if no current were acting, the plume will break up and the overall effectiveness is diminished. This problem can be overcome by increasing the velocity of the rising air bubbles. However, for a given nozzle there is a critical velocity above which additional increases in air volume have little effect on the magnitude of the surface generated current; i.e., the efficiency of the barrier is greatly reduced. The efficiency of the barrier improves in proportion to water depth; shallow waters require greater volumes of air."

In conclusion, air barriers have been demonstrated to be successful in quiescent waters. However, more work is required on determining the influence of orbital wave motion on the performance of an air barrier.

Oil Spill Cleanup Manual, prepared by The Standard Oil Company (New Jersey), 1969.

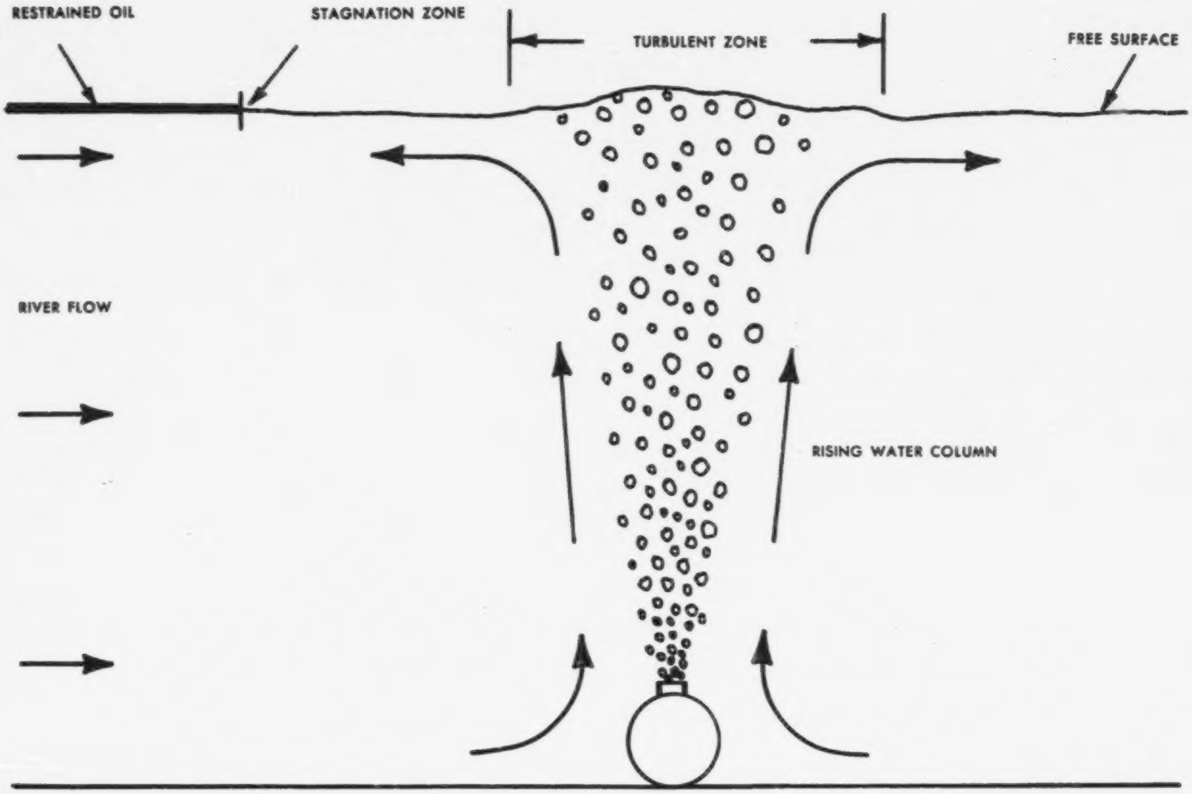
RESTRAINED OIL
STAGNATION ZONE
TURBULENT ZONE
FREE SURFACE
RIVER FLOW
RISING WATER COLUMN

Figure 30
AIR BARRIER EFFECT

HARMSTORF PNEUMATIC BARRIER

The Harmstorf Pneumatic Barrier has been commercially available for many years with extensive use in many locations throughout Western Europe and Northern Africa. Harmstorf employs a small diameter plastic pipe(s) properly weighted and placed on the harbor bottom. It is believed that the Harmstorf curtain produces a relatively small diameter bubble under small orifice conditions with relatively high pressure in the air delivery line.

Harmstorf's air barriers have generally been limited to harbor areas where surface currents do not exceed 0.8 - 1.0 feet per second. The cost of this barrier is approximately $30.00 per foot.

Product bulletins received from the Harmstorf Corporation, Germany. Materials also received from Spearin, Preston, and Burrows, Inc. - U.S. Representative for Harmstorf Corporation, New York, New York, 1968.

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OTHER TESTING OF PNEUMATIC BARRIERS

1. Ocean Science and Engineering Company at Santa Barbara, California.
2. Cornell Aeronautic Laboratories at Buffalo, New York. FWPCA Grant 11020DJG.
3. Maine Port Authority at Portland, Maine. FWPCA Grant 15080DOZ.

Since all of these projects are in the final testing phase, and/or preparing final reports, we have refrained from presenting any information on these projects until their work has been concluded and reported.

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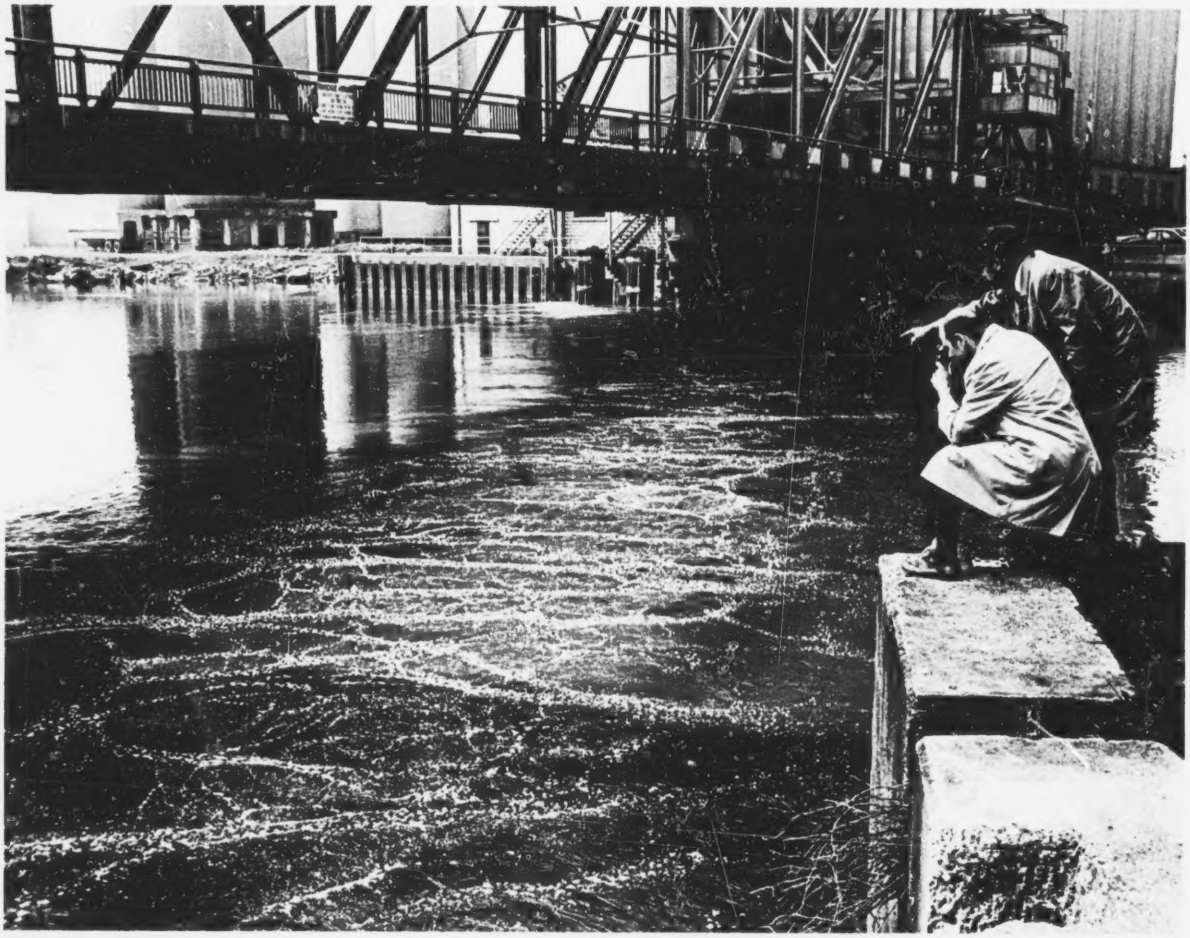

Figure 31 BUBBLE BARRIER, BUFFALO RIVER